



FEMA



TRAINING DOCUMENT

TITLE: IND Modeling and Response Planning
(National Capital Region)

TARGET GROUP: Radiological emergency responders and planners at the local, state and federal levels

TIME ALLOTTED: 90 - 120 minutes

INSTRUCTOR (s): Health Physicist with Response Experience

METHOD OF INSTRUCTION: Presentation

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Erika Olsen & Shaida Arbabha, DHS Scholars at LLNL

Date: July 2011

Instructional Goal

This module is intended to give an overview of actions responders and regional emergency management authorities can take to save and sustain lives.

Instructional Objectives

- Congress identified IND response planning as a priority and part of all-hazards response planning.
- IND analysis indicates significantly reduced prompt radiation and thermal effects from cold war planning.
- Identify federal IND specific response guidance.
- Understand that State and local planning is critical to reducing initial loss of life.
- Define prompt effects from a low-yield nuclear explosion
- Define Planning Guidance (damage) zones
- Review recent studies and current understanding of nuclear effects
- Review response strategies

Please provide feedback for these draft documents to brooke2@llnl.gov

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Handouts

Student Guide. If available, consider providing some of the references below

References

Recent research over the last few years has help greatly improve our understanding of appropriate actions for the public and responder community to take after a nuclear detonation. Much of this research was recently highlighted in [a National Academies Bridge Journal on Nuclear Dangers](#). This research points out the potentially misleading shelter / evacuation conclusions that can be drawn from using oversimplified modeling assumptions (a.k.a circles of prompt effects and cigar shaped Gaussian fallout patters using surface wind conditions).

Planning Guidance:

[Planning Guidance for Response to a Nuclear Detonation](#). Developed by the Homeland Security Council, 2nd Ed, June 2010. This interagency consensus document provides excellent background information on the effects of a nuclear detonation and key response recommendations. Its definition of zones (damage and fallout) are becoming the standard for response planning and should be integrated in the planning process.

National Council on Radiation Protection and Measurement (NCRP) Report No. 165 - [Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers](#) was released Feb 2011 and is a National Standard that supplies the science and builds on many of the concepts of the Planning Guidance.

For public Health information, an entire edition of the journal for [Disaster Medicine and Public Health Preparedness](#) was dedicated to the public health issues associated with the aftermath of nuclear terrorism. All of the articles are available for free download from the highlighted link.

[DHS Strategy for Improving the National Response and Recovery from an IND Attack](#), April 2010, is an Official Use Only document that breaks the initially overwhelming IND response planning activity down into 7 manageable capability categories with supporting objectives. This can be a valuable document to guide a state and regional planning process as a lot of work has already gone into time phased capability requirements for Doctrine/Plans, Organization, Training, Materiel, Leadership, Personnel, Facilities, and Regulations/Authorities/ Grants/Standards. Please contact Dave Sheehan, David.Sheehan@FEMA.gov or 202-212-1608 for more information or a copy of the document

The 30 minute video, [Reducing the Consequences of a nuclear detonation](#) is available on YouTube (click the title to view) and shows a presentation given last year at an LA County Public Health Conference. It provides a lot of information on DHS IND response planning research and demonstrates the very dynamic nature of an IND event. It was developed to provide “ground level” points of view and demonstrate the timing of the event and the consequences of different actions.

[Key Response Planning Factors for the Aftermath of Nuclear Terrorism](#) developed by Lawrence Livermore National Laboratory in support of the DHS preparedness activity was released in August 2009 reviews the science behind many of the recommendations noted in the video and above doctrine.

Title

This presentation is an overview of current Improvised Nuclear Detonation response planning activities within the federal government. This material was prepared for DHS by Lawrence Livermore National Laboratory. For more information contact Brooke Buddemeier (brooke2@llnl.gov).



Modeling Improvised Nuclear Device (IND) Impacts to Tier I UASI Cities

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1- IND response planning is a priority

Project Background

The Federal Budget Supplemental in FY07 provided funding to the DHS Office of Health Affairs to support IND response planning. Congress has continued to provide funding to FEMA in the FY09 and FY10 budget cycles.

2007 Budget Supplemental Engaged Community Planning Efforts



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Lack of Scientific Consensus

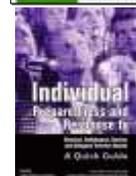
It is no wonder there is confusion at the Federal, State, and Local level on appropriate response actions, two very popular response planning guide list opposite instructions for the right action to take after a nuclear detonation.

Ready.gov recommends **“Take cover immediately, as far below ground as possible..”** but RAND recommends **“evacuate the fallout zone quickly..”**

We cannot afford to have this kind of conflicting guidance in the critical time period right after the detonation.

Lack of Scientific Consensus on Appropriate Actions

- Conflicting advice on basic issues such as **shelter or evacuate?**
- Many Cold War Civil Defense assumptions are invalid for nuclear terrorism.
- Updated analysis and planning low yield nuclear detonations in modern cities is required.



“Take cover immediately, as far below ground as possible..”
~ Ready.gov (DHS)¹

“Avoid radioactive fallout: evacuate the fallout zone quickly..”
~ RAND²

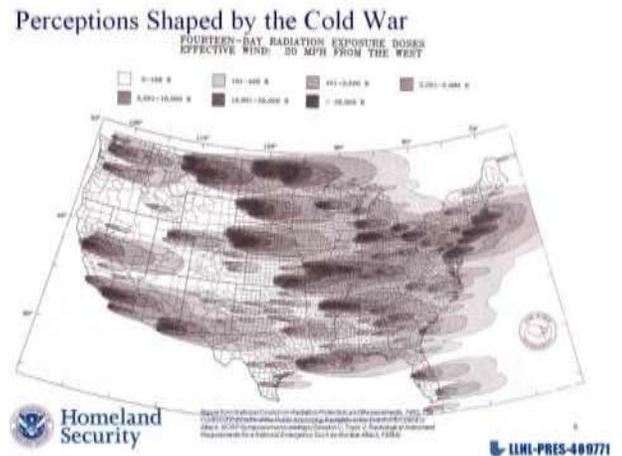


¹US Department of Homeland Security, <http://www.ready.gov/america/boisfordnuclear.html>
²Individual Preparedness Response to Chemical, Radiological, Nuclear, and Biological Terrorist Attacks: A Quick Guide
Lynn E. Davis, Tom LaTourrette, David E. Mosher, Lisa M. Davis, David R. Howell 30 pp. • 2005 • ISBN: 0-8330-3487-1

Perceptions Shaped by the Cold War

The Cold War specter of strategic thermonuclear war and mutually assured destruction, with the possibility of hundreds of nuclear strikes on our major cities and the majority of the United State covered with lethal fallout is thankfully greatly diminished. However, the possibility of nuclear terrorism still conjures the same sense of Armageddon.

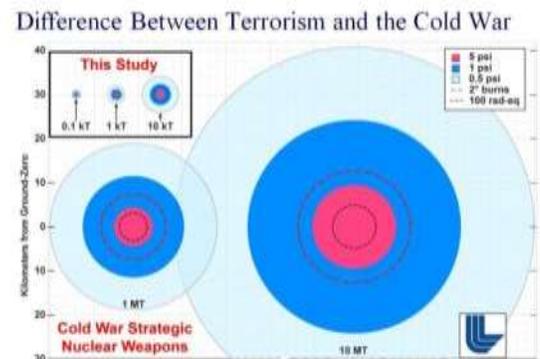
This map represents the aftermath of nuclear war, with the shaded areas on the map representing fallout radiation levels that would be enough to injure or kill the people that remain outdoors.



Difference between Terrorism and the Cold War

This slide shows the difference in prompt effects between a 10 Megaton device we could have seen during the Cold War and a low yield device we are concerned about for nuclear terrorism.

- As indicated in the graphics, the prompt effect ranges for improvised devices are significantly less.
- And in a terrorism scenario, we are only talking about one detonation instead of hundreds.



Observations on Starting Conditions

Based upon workshops that were conducted in 2008 across the United States, some observations allowed researchers to see the starting conditions of local and state communities

For state and local communities:

- While the slide says few, the reality is that **no** community had a coordinated *regional* response plan for the aftermath of a nuclear detonation
- On top of that, there is a general lack of understanding about what the response needs were, and the roles that the Federal, State, and Local authorities would have to play.
- Often there is a misimpression that a nuclear detonation would wipe out the response force and there would be nobody left to respond.
- Many response planners assumed that a nuclear detonation response would be led by the federal government.
- Unfortunately such assumptions led to apathy in planning that could get 100,000s of people killed or injured unnecessarily.

Why? The critical decisions that are made in the first few minutes and hours represent the greatest opportunity for saving lives.

- These decision have to be made at the local level, and
- are not likely to be technically informed, and the correct actions can be counter intuitive

In addition, there was a lack of scientific consensus on what the appropriate actions to take actually were.

Observations on Starting Conditions

- State and Local Communities:
 - Few have a coordinated response plan for the aftermath nuclear terrorism,
 - There is a general lack of understanding of the response needs, and
 - Uncertainty of the Federal, State, and Local roles and responsibilities.
- Decisions made in the first few hours:
 - Have the greatest public health and medical impact and
 - Are *not likely to be technically informed*
(correct actions can be counter-intuitive)
- Lack of consistent guidance on response strategy



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MACWG

To address the lack of scientific consensus, the Department of Homeland Security established an independent scientific working group called the IND Modeling and Analysis Coordination working group or “MACWG” for short.

- Comprised of the technical organizations that support federal government agencies, this group is working to collaborate and come to consensus on as many issues as possible to support IND response planning

Before we move into recent science, I want to share an important quote by Statistician [George Box](#); *“Essentially, all models are wrong, but some are useful”*

- Although the information you are about to see may look very exact, it is just an estimate based on one of many possible input parameters and equations. The models were developed based on data from our nuclear tests, but only a handful of these test were conducted in a way that was even close to the ground level, low yield detonation we are assessing here.
- It is important that you **do not believe in the accuracy of the specifics of the model** results (i.e., a specific building was damaged in a specific way, or that a specific town will be contaminated with fallout while another town would not be), **but rather note the trends of the assessments.**
- Even if the models were perfect, recognize that these are models of one possible yield, at one possible location, with one possible weather pattern and the probability that it will actually look like that are just about nil.

Scientific Working Group Established

- The **Modeling and Analysis Coordination Working Group (MACWG)** was established to:
 - Establish scientific consensus (where possible) on the IND effects and consequences.
 - Bound uncertainty and identify unknowns, and
 - Deconflict recommended IND response actions.
- This working group is a coordination point for the Department of Homeland Security *limited modeling and analysis work on IND response planning*. Other organizations with interest and relevant efforts or expertise invited to attend to encourage process transparency and collaboration.

Participants:

- | | |
|--|--|
| <ul style="list-style-type: none"> • Department of Homeland Security <ul style="list-style-type: none"> • Office of Health Affairs • Science and Technology • Domestic Nuclear Detection Office • Policy • Lawrence Livermore National Laboratory (LLNL), Chair • Sandia National Laboratory (SNL) | <ul style="list-style-type: none"> • National Infrastructure System and Analysis Center (NISAC) • Homeland Security Institute (HSI) • Defense Threat Reduction Agency (DTRA) • Science Application International Corporation (SAIC) • Applied Research Associates (ARA) • Los Alamos National Laboratory (LANL) Consequence Modeling • Institute for Defense Analysis (IDA) • Gryphon Scientific |
|--|--|



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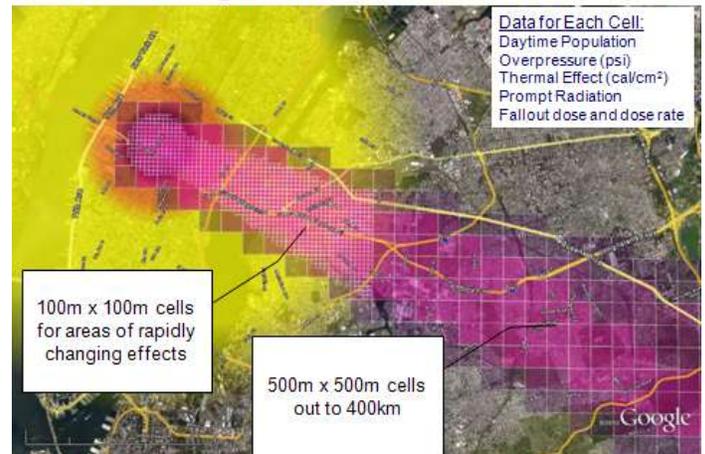
3- Analysis of IND Effects

Advanced Detailed Analysis

Detailed urban information combined with advanced modeling capabilities has resulted in unprecedented improvements in the understanding of nuclear detonation effects in a modern urban environment. For example, detailed day and night time population density and 3-dimensional urban terrain modeling have allowed for an unprecedented, “block by block,” analyses of nuclear detonation effected in the urban environment. Each 100m x 100m block in a city can be evaluated for the prompt blast, thermal, and radiation effects. Fallout arrival and decay can also be evaluated in each block of a city, allowing for unprecedented community specific response strategy optimization analysis.

Building specific information can provide detailed injury assessment to provide for advanced public health response planning.

Detailed Population & Effects Information

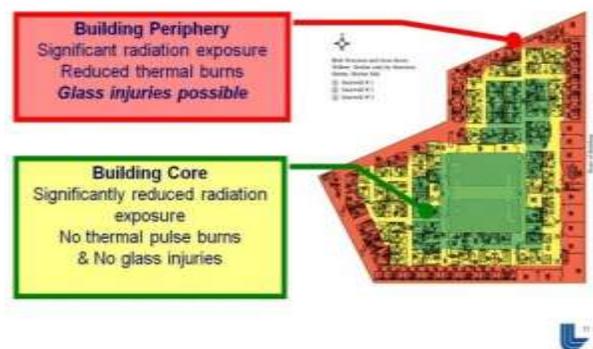


OPTIONAL: Modeling the Effects to People inside Buildings

Although it may sound strange, most models do not include building effects, rather they model the effects to the population of National Capital Region *{update with city of interest}* As if they were standing the Nevada Desert next to the detonation.

The updated injury modeling by the Department of Homeland Security takes buildings into account. Buildings can both protect and injure their occupants from the effects of a nuclear weapon. In addition to modeling how modern urban buildings interact with blast effects, the distribution of personnel within building is being evaluated for an overall injury assessment.

Modeling Effects to People INSIDE buildings

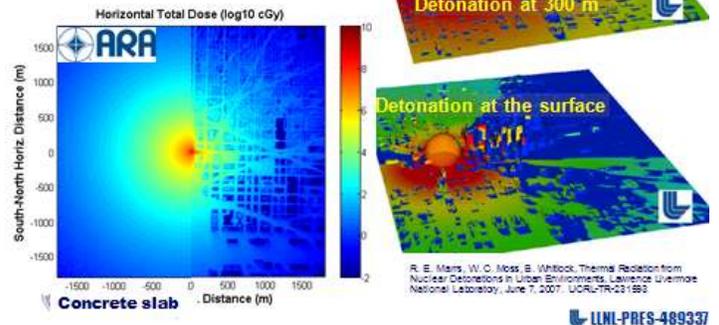


Evaluating Line of Sight

- The protection afforded by the urban environment can greatly reduce the number of previously calculated burns that have been cited in many previous studies.
- The image on the top right indicates the thermal effect for a 10kT detonated 300m over the OK City bombing site. You can see how the “circles of effect” are a pretty good representation of injury.
- Click – the lower image is the SAME YIELD and SAME LOCATION, but now detonated on the ground so you can see the level of protection afforded by the urban environment. The blue and green areas on the map are areas of little or no thermal burns.
- On the left is the image of the radiation exposure coming off of a nuclear device 1 meter over a concrete slab,
- Click - when the DC urban environment is added in, you can see how the radiation is also mitigated and, unless you are looking at the detonation down a line of site roadway, the DC environment can reduce the exposure by a factor of 10 or more.

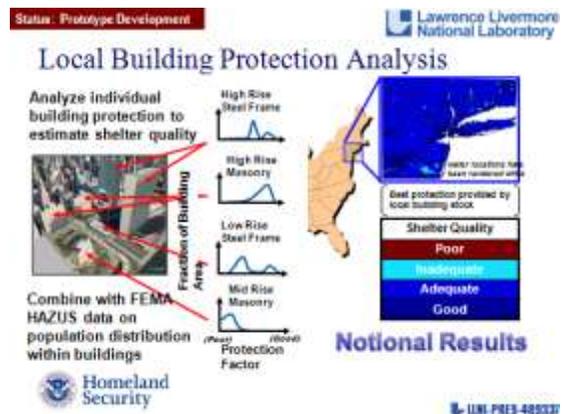
Updating the Supporting Science

- Burns from the fireball traditionally considered a primary health effect. Buildings may mitigate.
- Prompt Radiation can also be greatly affected by the urban environment



OPTIONAL: Regional Shelter Evaluation

- Maps of Indoor fallout exposures can be created by combining regional shelter quality assessments with outdoor radiation estimates. The assessments are being performed at Lawrence Livermore National Laboratory by integrating national geospatial building information with an updated assessment of building protection factor analysis
- This helps determine the efficacy of various



shelter or evacuation strategies. The bottom left image is that of outdoor exposures exceeding 10 R in 24 hours. The bottom right exposure is calculated INDOOR exposures that exceed 10 R, dramatically demonstrating the reduction of exposures.

Products of the Prototype Svalin Shielding Model

- Maps of Regional Shelter Quality
 - Local Shelter (best nearby shelter)
 - Shelter in Place (best shelter within a building)
 - No Response (people stay put)
- Maps of Indoor Radiation
 - Combine regional shelter quality with outdoor radiation estimates.

Outdoor Radiation



Prompt: 10 R Gamma Isodose

Regional Shelter Quality



Local Shelter

Indoor Radiation



Prompt: 10 R Gamma Isodose

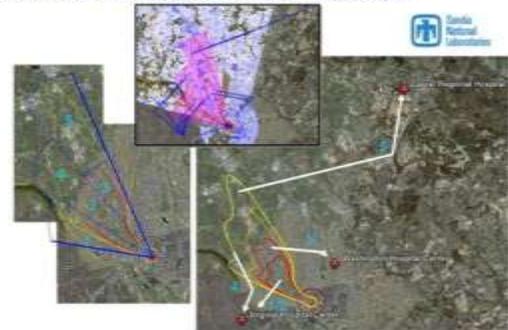

 Homeland Security


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OPTIONAL: Shelter / Evacuation

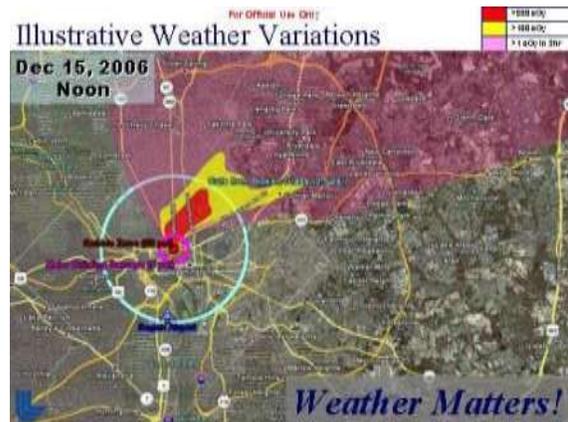
As previously demonstrated, the shelter and evacuation strategy will likely be the most relevant analysis in regards to the appropriate response. New analysis and tools developed at Sandia National Laboratory take the detailed 100mx100m prompt and fallout analysis files generated at Lawrence Livermore National Laboratory and provide community specific shelter and evacuation optimization analysis.

Shelter / Evacuation Evaluation



Weather Matters

Another key advance in recent decades is the ability to do 3 dimensional weather modeling. Previously, simple fallout models assumed uniform wind direction and speed at all levels of the atmosphere. This resulted in “Gaussian” fallout patterns (that is the classic “cigar” shape) that gave an unrealistic impression that fallout was conveniently confined to long, narrow patterns, like...
 this fallout pattern from noon on Jan 15th 2006. Unfortunately the heat of a nuclear explosion will drive the fallout cloud several miles into the upper atmosphere. Real atmospheric conditions often have different wind direction and speeds at different heights.
 As a demonstration of weather variability, I will show you the fallout patterns for the 15th of



each month in 2006 using the 3 dimensional weather analyses. Observe the variability of weather patterns and directions.
Notice how many “Gaussian” patterns there are (count ~ four of them.. the ones where the red portion does not diverge)

The NCR Scenario

The following slides represent the results of modeling for one particular scenario of a 10 kT improvised nuclear device being detonated in downtown DC. This is similar to National Planning Scenario #1.

☞ **Click – Light of a Thousand Suns...appears**

The detonation of an improvised nuclear device would produce a flash of light that is equivalent to a thousand mid-day suns at a mile away.

A 10kT yield is about equivalent to the explosive power of 5,000 Oklahoma City Truck Bombs

For this scenario, we used;

- The detonation took place on the ground level at 1600 Kst NW
- The population estimates are based on a typical workday
- The weather profile is taken from actual weather conditions on Feb 14, 2009

The information from these slides may be used to model a detonation in other large cities, although similar response planning information guides are being created for other Tier 1 cities.

☞ **Slide Transition –Animation on flash blindness begins**

NCR Example: Downtown 10kT

The Light of a Thousand Suns

seen at 1 mile for those with line of sight

- Scenario Presumptions:
 - 10kT Yield (equivalent to 5,000 Oklahoma City Truck Bombs)
 - Ground Level Detonation at 1600 K St. NW
 - Fallout Predicted using Weather from noon on Feb 14, 2009
 - Casualty Numbers Using Daytime Population Estimates

The above slides contain modeling and analysis and other data that have been developed for the purpose of this presentation. The information presented is for informational purposes only and is not a forecast. The information should be used as a guide only and should not be used for any other purpose.



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2- Prompt Effects

Flash Blindness

The bright flash of light produced by the Detonation of an IND can temporarily blind anyone who sees it within a few miles. This blindness may last for several seconds to, perhaps, minutes. Not a big deal if you are standing on a street corner, but could be a pretty big deal if you are driving 60mph down the freeway. We can expect most roads within a 10km range to be snarled with accidents and many injuries would occur.

Accidents and Congestion Caused by Flashblindness



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🖱️ **Slide Transition –Animation of zoom-out begins**

- It can be expected that most roads within about a six mile range will be snarled with accidents and many injuries would occur.
- The potential for flash blindness would be worse at night time, and could cause accidents much further out.

Accidents and Congestion Caused by Flashblindness



Severe Damage Zone

The federal Planning Guidance identified three major blast damage zones. Those three zones are:

- Severe damage zone
- Moderate damage zone
- Light damage zone

The zones are defined by the amount of **observable** damage caused by blast effects.

- Blast effects are the damages/injuries done to structures/people following the detonation.

🖱️ **Click –#1- Red dot appears**

The red dot is where the 10 Kt device is located

- 1600 K St NW

🖱️ **Click –Severe Damage Zone appears**

In this scenario, the severe damage zone extends to about half a mile from the blast site.

- This zone will see severe structure damage from the initial blast wave,
- and most likely fatal injuries from the blast, thermal pulse, and prompt radiation effects we just talked about.



Underground Damage

The shockwave movement underground also creates damage to tunnels, such as subway systems, and infrastructure such as water mains, power, telecommunications, and gas conduits.

Analysis by Los Alamos National Laboratories using data from nuclear tests at the Nevada Test Site and extrapolation from earthquake damage of the effects on these systems indicate that:

Water, power and Telecommunication conduits may be damaged out to 120 meters from a 10 kT surface detonation.

Larger tunnels, such as subway systems may be damaged out to 250 meters (~ 2 city blocks) from a 10kT.

Pipeline and Tunnel Damage with Ground Shock



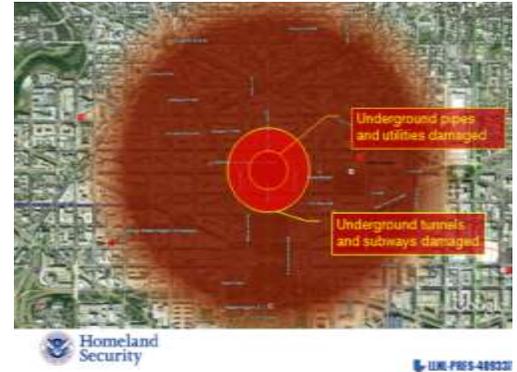
Lifeline damage/disruption based on scaling surface explosion results:
10 kt: up to 120m
1 kt: up to 55m



Extrapolation Nevada Test Site experience suggests significant subway damage to ranges of:
10 kt: 200-250m
1kt: 90-120 m

Underground Damage in comparison to Above Ground Damage

Since the Severe Damage Zone extends ~ ½ mile (~800m), this means that the primary underground infrastructure damage is contained by the Severe Damage Zone



Outer Edge of Severe Damage Zone

Structures within to the Severe Damage Zone are not likely to remain standing. Even at the outer edge of the SDZ, the damage will be significant.

To give you an idea of the type of destruction at the outer edge of SDZ, these pictures, from a test detonation in the Nevada desert, demonstrate the damage done to buildings at the edge of the Severe Damage Zone.

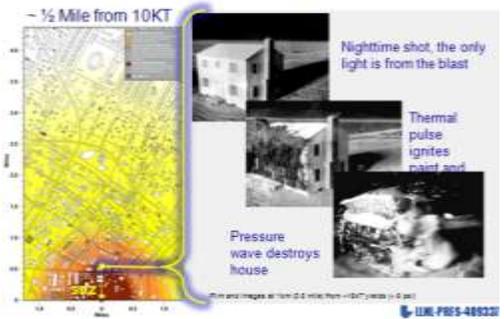
Note that since there were not any intervening buildings (as there would be in a city) the house has line of sight view of the thermal pulse and starts to burn before the blast wave arrives.

To give you an idea of the timing of such destruction, this real time video will show how the even unfolds when this close to the detonation.

 **Click –Video of detonation begins**

The initial thermal pulse starts the house on fire. The blast wave comes first as positive pressure which rips the house apart. This is followed by negative pressure moving the opposite direction. Severe radiation and burn injuries will occur, especially to those outdoors.

Outer Edge of Severe Damage Zone (SDZ)



Moderate Damage Zone

The orange ring encompasses the moderate damage zone.

- For a 10kT, it will extend from ½ a mile to one mile from the detonation site, and this area has the most potential life saving opportunities.
- building damage is substantial; a distance of about 1 mile from ground zero; observations include *significant structural damage, blown out building interiors, blown down utility poles, overturned automobiles, some collapsed buildings, and fires*; sturdier buildings (e.g., reinforced concrete) will remain standing, lighter commercial and multi-unit residential buildings may be fallen or structurally unstable, and most single-family houses would be destroyed;
- visibility in much of the MD zone may be limited for an hour or more;
- Prompt radiation and thermal effects from the detonation may cause injuries, especially to those outdoor with a view of the fireball.
- Substantial rubble and crashed/overturned vehicles in streets; rubble will completely block streets and require heavy equipment to clear; broken water and utility lines are expected and fires will be encountered;
- many casualties in the MD zone will survive and will benefit most from urgent medical care



Outer Edge of Moderate Damage Zone

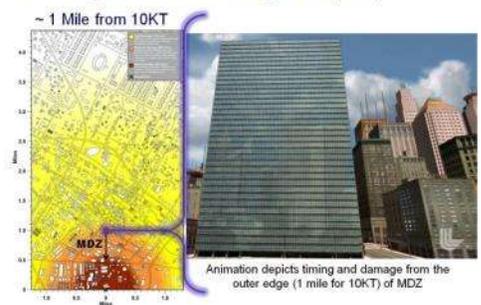
- The outer edge of the Moderate Damage Zone typically shows building damage consisting of broken glass and partial destruction of weaker structures.
- This animation depicts the timing and type of effects that might be observed on the outer edge of the moderate damage zone.

 **Click –Movie of breaking glass from blast begins**

This animation depicts the timing and type of effects that might be observed on the outer edge of the moderate damage zone.

- The bright flash will be followed by a “thump” as the shock is transmitted through the earth.

Outer Edge of Moderate Damage Zone (MDZ)



- This will be followed in several seconds by the air blast which will severely damage many structures and blow the glass into building causing injuries and bringing the façade of many building tumbling into the street.
- This will also create rubble and debris in the street which can impede the progress of responders and evacuees.

🖱 **Slide Transition –Image grows and LDZ appears**

Light Damage Zone

Click #1- MDZ shrinks

The last blast zone is the light damage zone.

Click #2 – Glass breakage ring appears as does man with glass flying towards him.

Although windows will be broken 10 miles away, The light blue line is where glass is broken with enough force to cause injuries. This occurs out to 3 miles in this 10kt scenario. The D.C. population during the workday in this area is about 850,000 people.

Click #3 – Glass Flashblindness

The white area that appears is the area where people outside have the potential to be blinded by the brilliant flash that appears during detonation. This blindness may last for several seconds, or as long as a couple minutes. The potential flash blindness is not expected to be of issue for pedestrians, however, drivers will be unable to see the road or other drivers which could potentially cause additional accidents clogging major thoroughfares. Because of that, we can expect most roads in about a 10km range to be snarled with accidents.

Click #4&5 – EMP

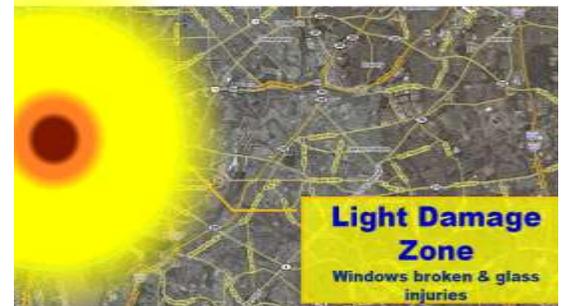
Another area of concern is the EMP range. EMP is the electromagnetic pulse that will radiate outwards from the blast site. The most damaging EMP effects will be limited to within a mile. An EMP blast will disrupt most electronics, but cause little direct harm to people. Disruptive Effects, such as system latch-up which require power cycling to clear, can occur out to 3-5 miles (quote from planning guidance)

Click -Light Damage Zone

Which all helps define the last blast zone, which is the light damage zone. This extends from one to three miles from a 10KT and represents the largest of the three blast zones. The majority of injuries within this zone consist of cuts from broken glass. There will also be minor structural damage, mainly consisting of the destruction of large, weak and flat surfaces.



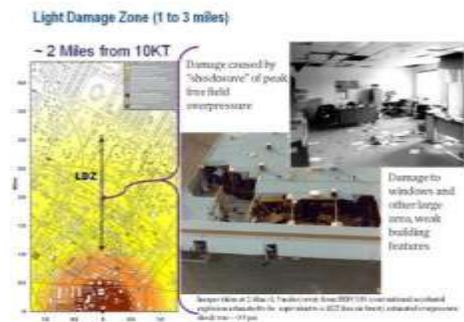
Light Damage Zone



Examples of Damage in the Light Damage Zone

The damage in this area is caused by the “shockwave” following the blast. This is similar to a “sonic boom” and consists of free field overpressure.

- The images to the right are a mile and half from an accidental explosion in Henderson Nevada of a booster rocket manufacturing facility. The explosion was estimated to be the equivalent of ~ 1KT.
- As can be seen in the image, the office glass has been blown into the building and the ceiling tiles have caved in. The large flat roof of the warehouse also collapsed.
- Injuries in this area are expected to be survivable lacerations and minor crush injuries.



Optional Slides (if the MACWG research is not discussed)

Before we leave the discussion of prompt effects, we need to address some findings of recent studies

The first has to do with the Urban Mitigation of Line of Sight Effects

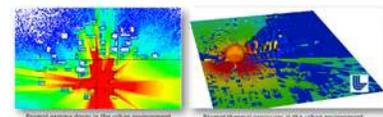
- You may have noticed on the previous slides that the prompt damage zones were perfect circles.
- That’s because until recently, most models of prompt effects were based on an open plain scenario (like the Nevada Desert).
- But the buildings in an urban environment will absorb some of the prompt effects and they can greatly reduce thermal burns and radiation exposure

These images, which model a ground level, low yield nuclear detonation, demonstrate how some types of radiation and thermal effects are greatly mitigated by the urban environment.

- The blue and green areas on the images represent low (or survivable) exposure levels.

Without the urban environment, harmful levels of gamma radiation and thermal burns could extend into the moderate damage zone.

Urban Mitigation of Thermal and Ionizing Radiation



- The green and blue areas represent low exposure levels
- The urban environment reduces the range of ionizing radiation and thermal effects
- Effects are non-uniform (not perfect circles)

Source: Health Effects from a 100 kt Detonation
 Prepared by the MACWG, 10/12/2010

Optional Slide: Actual Building damage...

The circles of blast effect can also be misleading.

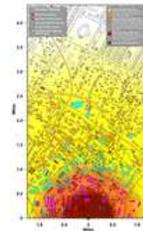
- Blast “waves” can be greatly modified as they move through the urban environment.
- The overpressure can be reflected off of buildings, channeled down streets, and even reflected off of different layers of the atmosphere.

You can see that some building collapse beyond the range predicted by the ideal air blast model because of this phenomenon.

- Also, some buildings can survive unscathed fairly close to the detonation.

So the ranges for these effects are not uniform, and perfect “circles” depicted on earlier slides should be taken as examples of maximum ranges and not an average range.

Actual Building Damage Not Represented by Rings



- Damage depends on building type,
- Blast wave propagation through the urban environment, and
- Reflection off of atmospheric and geographic effects.

Summary of Prompt Effects

- **Many existing models will over-predict thermal and prompt radiation effect ranges in the urban environment**
 - Responders should be aware that while they should not initially enter areas with dangerous fallout levels, these levels will fall quickly
- **Blast will be a primary injury mechanism and can cause damage and injury several miles from the detonation site**
 - **100,000s casualties** can occur from the prompt effects in the first few minutes within a few miles of detonation site,
 - Overall number of casualties likely to be reduced by protection from the urban landscape and being within heavy buildings, however
 - Tertiary effects (building collapse, glass and debris missiles, and flash-blindness accidents) may increase number of casualties.
- **Federal planning guidance has defined several damage zones based on observable effects**
 - Severe Damage – responders should not focus on this area, as radiation levels will be too high and survival is unlikely
 - Moderate Damage – This should take highest priority as there is the highest potential to save lives
 - Light Damage – This is a lower initial priority, as most injuries can be treated with minimal or no medical care.

Summary of Prompt Effects

- Many existing models will over-predict thermal and prompt radiation effect ranges in the urban environment
- Blast will be a primary injury mechanism and can cause damage and injury several miles from the detonation site
- Federal planning guidance has defined several damage zones based on observable effects
 - Severe Damage, not an initial priority
 - Moderate Damage, high priority area for life saving
 - Light Damage, lower initial priority
- Fallout radiation hazards may exist on **some parts** of these zones, the safety precautions described in the Fallout section take precedent.

- **Fallout radiation hazards may exist in some parts of all zones. Safety precautions should be taken within every zone**

FALLOUT

Use the talking points below during the movie, or (optionally) you can just display the bullets and talk through them and not use the movie if there is a problem with sound or playback.

Click to start Movie

After the Prompt Effects, the primary delayed effect from a ground-level nuclear detonation is from “fallout.”

- Fallout is generated when the dust and debris excavated by the explosion is combined with radioactive fission products and drawn upward by the heat of the event.
- This cloud rapidly climbs through the atmosphere, up to five miles high for a 10kt, and highly radioactive particles coalesce and drop back down to earth as they cool.
- Larger particles will fallout first, and within several miles of the detonation these may be the size of table salt or sand. The further from the detonation, the smaller the particles will become.
- The hazard from fallout comes not from breathing in the particles, but being exposed to the **penetrating** radiation they give off after they have settled on the ground and building roofs.

But if we can find adequate shelter, we can protect ourselves from the most harmful effects

FALLOUT

- Fallout is generated when thousands of tons of excavated by the explosion is combined with radioactive fission products and drawn upward by the heat of the event.
- This cloud rapidly climbs through the atmosphere, up to **five miles high for a 10kt**, and highly radioactive particles coalesce and drop back down to earth as they cool.
- Within 10 – 20 miles of the detonation, particles will be the size of table salt or sand as they **fall back to earth contaminating horizontal surfaces**.
- These particles give off **penetrating radiation** that can injure people (even inside cars or inadequate shelter)
- **Fallout decays rapidly away with time**, and is most dangerous in the first few hours after the detonation

Fallout

Looking to the North on the DC area

Blast effects are the damages/injuries done to structures/people following detonation. The severity of the effects changes based on set zones. The zones are defined by proximity to “ground zero” and are categorized by amount of damage, radiation, injury level, etc.

Click - The Prompt effects can be seen

Click –Fireball/Mushroom cloud appear

The fireball will quickly gather material from the ground and head upwards into the atmosphere.

- The dust and debris at the base is generated from blast effects and is generally NOT radioactive.
- The material in the “stem and cap” of the fallout cloud is highly radioactive
- Under ideal circumstances this will create a "mushroom" shaped cloud, however this may not be the case for low yield or non-ideal wind conditions.






Fallout Particles Move Away in Various Directions and Speeds

The upper level (high speed) winds sweep the cap of the cloud to the East.

Lower altitude, low speed winds move the “stem” and the particles coming down from the upper atmosphere to the North







Transition movie to view cloud at 15 minutes after the detonation.

This image represents how fallout travels over a period of about six hours. Depending on weather conditions and wind speed, dangerous fallout particles will move away from the initial blast site in different directions at different speeds.

As this animation unfolds for the first six hours after a 10KT detonation, you will see two things:

- (1) The purple balls represent the fallout cloud movement
- (2) The colored contours on the ground represent the different radiation levels being given off by the particles that have fallen on the ground.

 **Click –Animation of the fallout cloud’s initial movement begins.**

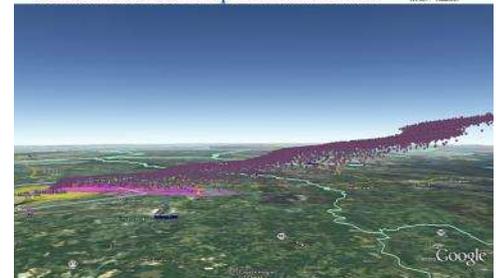
The upper atmosphere winds push it off to the East while parts of the fallout in the lower atmosphere push it off to the North. The different colors represent fallout levels on the ground. After just the first hour, most of the cloud moves away, but the dangerous radiation remains present on the ground.

 **Click –Animation continues, showing the remainder of a six-hour period.**

It is important to remember that even though you might not be able to see any type of cloud after the first hour, dangerous radiation levels will remain. Understanding how radiation remains behind following the detonation is a key response issue.



Fallout Clouds Drop Contamination **:15**
Hour Minute



Fallout Clouds Drop Contamination **6:00**
Hour Minute



Fallout Clouds Spread Rapidly

- 🖱 **Slide Transition –Animation begins showing the fallout cloud over a larger area.**

Note how the radiation level on the ground lags significantly behind the movement of the fallout cloud. This is because the fallout particles have to fall from several miles in the upper atmosphere.

First hour: Cloud over Atlantic

The cloud moves away quickly, but has already deposited dangerous levels of radiation over areas near the detonation site. At 1 hour the top of the cloud has already over the Atlantic Ocean

Click - 2 hours: over BWI

The lower half of the cloud continues to move away from the detonation site and continues to deposit some fallout. This part of the cloud reaches BWI after ~ 2 hours

Click - Animation continues to show the spread of the fallout cloud

Even though the cloud continues to spread over large areas, the radiation dose to areas below continues to lessen. The good news about fallout is that it does decay quickly. This means the radiation levels in areas where the fallout has already been deposited will lessen over time.

1 Week after the event, the “Hot Zone” which is where the planning guidance recommend special controls for working in the area has shrunk down to 30 miles long



OPTIONAL: DHS and EPA Guidelines on Exposure Levels

Although there are current guidelines for shelter or evacuation, they were designed for slowly evolving events like a possible nuclear power accident.

These recommendations indicate that you should **consider** shelter or evacuation when a four day outdoor exposure would exceed one rem, and shelter or evacuation is warranted if expected exposure exceeds five rem.

Unfortunately it fails to actually tell you which (shelter or evacuation) is the better option, instead stating that you should choose the option that leads to the lowest possible exposure and leaves the evaluation to be performed on the fly.

These figures demonstrate why having response plans is so crucial to saving lives, as figuring out what to do with several million people after the detonation is likely to be impossible.

Current DHS & EPA Guidance Focus on Low Level Exposures for Cancer Avoidance



Early Phase Evac Shelter PAGs (12-108 hrs)

Actions and Long-Term Effects

Description	Level (rem)	Extent	Area	Population
Exceeds upper limit early phase PAG for evacuation/sheltering.	>5	59.8km	614km ²	702,000
Exceeds lower limit early phase PAG for evacuation/sheltering.	>1	200km	4,088km ²	1.49E6

Note: Areas and counts in the table are cumulative. Population Source = LandScan USA V1.0.

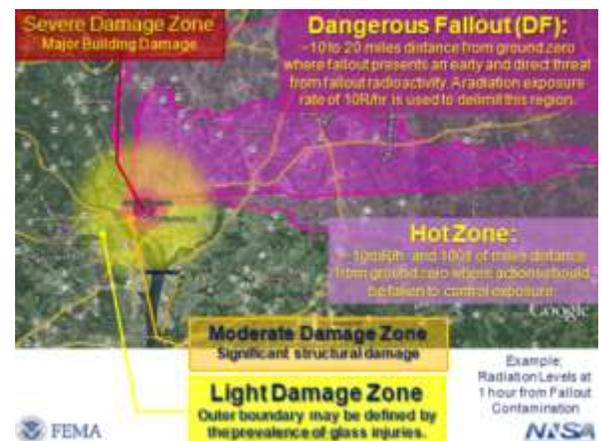
The 5 Zones

- **Severe Damage Zone**
- **Moderate Damage Zone**
- **Light Damage Zone**
- **Dangerous Fallout Zone**

Here is some more crucial information about the DFZ:

- **Bounded by radiation levels of 10R/hr** – determining dose rates early on helps to identify the perimeters of the DFZ
- **Could reach 10-20 miles downwind** – it is important to know weather conditions for the day, to help determine how far, and where, the DFZ will extend to

After establishing the perimeter of the DFZ, everyone should be aware that entering that area can cause acute radiation injuries or death. Responders should enter this area only voluntarily, and only after being fully informed of the risks



- **Hot Zone**

Although it is not life threatening, responders need to be aware that there are significant areas outside of the DFZ that have radiation levels that will be easily detectable, and may even saturate many of the instruments.

- Bounded by radiation levels of 10 mR/h (1/1000th of the DRZ)
- For a 10KT, could extend 100s of miles
- Reaches maximum extent at ~ 1 day
- Extended Response Actions will NOT result in significant exposures (100 rem)

It is important to emphasize that response operations can and should continue in this area, though additional precautions are warranted to ensure that responders do not spend unnecessary time in the area

Dose Rates Decay Quickly

- 🖱 **Click – Animation showing detail of detonation area begins**

Simply understanding how fallout works is not enough. It is important to understand what the event will look like from a first person perspective of the event.

- 🖱 **Click – View from South**

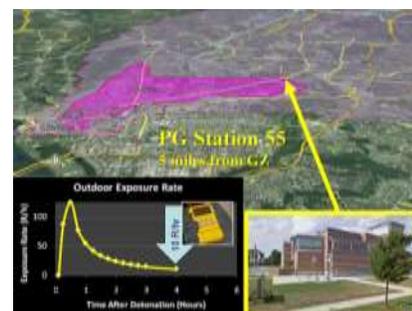
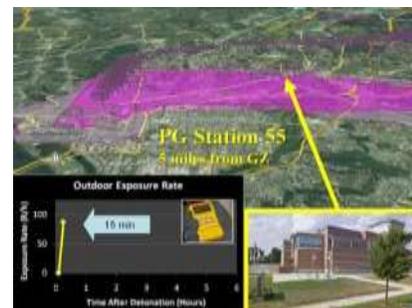
This animation shows what things will look like from someone in the Prince George’s County Firehouse #55. This station is 5 miles away from the detonation

- 🖱 **Click – Fallout cloud appears; dose rate in first 15 minutes appears**

The fallout cloud is already overhead, but not all of the fallout has reached the ground, so the radiation levels will continue to rise for several minutes. As the cloud reaches them, dose rates will shoot up over 100 R/hr at the half hour mark. This is over 10 times the 10 R/hr of the Dangerous Fallout Zone.

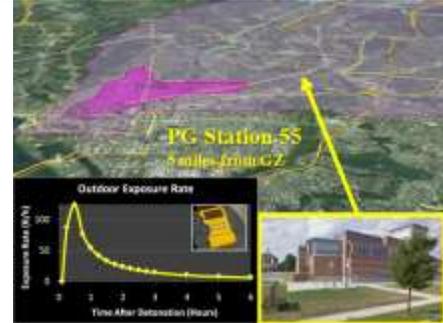
- 🖱 **Click – Animation continues showing dispersing fallout cloud and different dose rates**

While initial dose rates are high, look how fast the rates begin to drop. This is because radiation has an extremely short half-life; it decays very quickly. Over half of the



dangerous radiation dose comes from the first hour of exposure.

After 4 hours the Dangerous Fallout Zone “shrinks past” the station as dose rates fall below 10 R/h



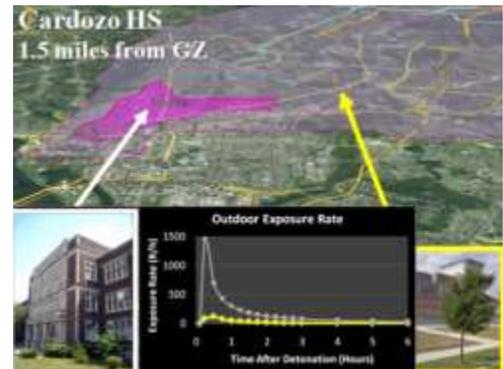
Cardozo HS measurements

To understand the difference distance makes, lets look at a location only 1.5 miles from the detonation. Cardozo High School

Click – Since they are a lot closer to the event, we will have to expand the scale on our dose rate chart.

Click - 15 minutes after the event, the fallout has already fallen at their location and exposure rates are ~ 1,500 R/h

But, again, watch the trend. Se how rably the dangerous levels of radiation fall off with time.



Key Fallout Considerations

Now let’s summarize what we just learned about fallout. While it can be lethal, it decays rapidly

- Radiation levels are very high initially, but over 50% of the energy is given off in the first hour. Over 80% in the first day.

Click –Animation starts/The primary hazard from fallout is being exposed to penetrating radiation from the particles
The concern with fallout is the exposure to penetrating radiation from the particles

- Getting as much distance and mass between you and the particles is the best protection.
- By remaining indoors and seeking the best possible shelter in the structure they’re in, people can dramatically cut down the radiation dose they receive. We’ll get into more detail in the

Key Fallout Considerations

- **Fallout Decays Rapidly** (releasing more than half of its energy in the first hour)
- The primary hazard from fallout is being in exposure to penetrating radiation from the particles
- Dangerous levels of fallout is readily visible as it falls
- Fallout is not a significant inhalation hazard
- The radiation penetrates through windows and walls, but exposure decreases with distance and intervening materials.



next section.

- 🔗 **Click –Dangerous levels of fallout are readily visible as they fall**
The most dangerous particles can be seen as they fall
 - They are not invisible, but they are often the size of salt or sand. Once on the ground however, you may not know if you are in a fallout contaminated area.

- 🔗 **Click –Fallout is not a significant inhalation hazard**
Fallout is not a significant inhalation hazard.
 - Because they are so large, breathing in the particles is not very likely and is a much lower concern than the external exposure from the particles on the ground.
 - We'll discuss this aspect further when we start talking about proper PPE during the response module.

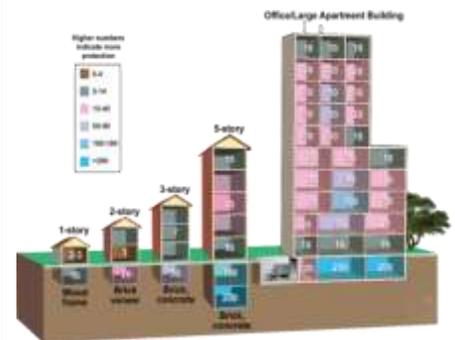
- 🔗 **Click –Animation of shelter protection factors begins**
In this animation, Note how the fallout comes to rest on horizontal surfaces like the ground and rooftops and then penetrates inside.
 - But the farther you are away from the walls or rooftops, the less radiation you'll receive.

This figure is similar to the animation we just saw and it introduces the concept of Protection Factors associated with different types of buildings.

- The Protection Factors -- or PFs -- that we're using here are similar to the SPF of sunscreen
- The higher the PF, the lower the exposure that a sheltered person would receive compared to an unsheltered person in the same area.
- To obtain the sheltered exposure, divide the outdoor exposure by the PF.

Here we're showing the presumed protection factors for a variety of buildings as well as the different locations within the building.

So in sum, if you are in a fallout area, knowing locations with adequate protection factors could prevent a potentially lethal exposure.



2- What Sheltering Can Do

[Advance has animation that zooms in on Cardozo HS. Talk the following while it moves]

To help illustrate the type of buildings you would find in a typical DC neighborhood, this animation focuses on a neighborhood around the Cardozo High School.

- This area is ~ 1.5 miles from the detonation and in the light damage zone. So it probably has blown out windows and some pressure damage but it is still standing and not on fire.
- Unfortunately, Cardozo and its immediate surroundings are in the Dangerous Fallout Zone

If you were this guy and simply stood outside in the first 12 hours following detonation, your dose rate would be 1,500 rem! As I said earlier, you don't need to understand all the terminology, but let me outline the potential effect...

☞ **Click –Color-coded bar appears**

As you can see, a dose that high would be enough to almost certainly kill you.

☞ **Click –Light structure range appears**

So you look around and see a 1-2 story wood-frame house with no basement. You know that's not adequate because it has a PF less than 10, but it would still be better than outside.

- Unfortunately, in this particular location, it is not enough to prevent a significant exposure so you keep looking.

☞ **Click -2/3 story commercial structure range appears**

If you sought shelter in a brick residential location instead -- like the brownstone row homes pictured --or in a small commercial facility, you could find protection factors up to 50.

- The Top Floor of one of these buildings would have a PF of 5 – 15
- The 1st floor's PF would be 10 and the 2nd Floor would be 50.
- This is where you'd receive survivable exposures.

☞ **Click –Multi-story commercial structure range appears**

But if you were really paying attention, you'd find shelter in a large, multi-story commercial building, such as Cardozo High School.

- There your radiation dose will be so minimal that you would



not likely experience any acute symptoms from the radiation.

How much time after an IND detonation occurs do you have to find adequate shelter – or to move from one shelter to another with a higher PF – before the Dangerous Fallout lands?

- This is where scientists usually say what first responders and emergency planners hate to hear “it depends”

The reason “it depends” has to do with how far you are from Ground Zero and Wind speed

- In The case of the area around Cardozo High School, the answer is less than 15 minutes.

But neither the public -- nor first responders for that matter – will know that.

As a result, a good rule of thumb is several minutes if you are outside the moderate damage zone.

How Many Lives Does It Save?

FEMA modelers conducted an analysis of the potential exposures from a variety of sheltering options for the first 24 hours after the detonation of a 10KT for this DC scenario. These are only fallout injuries **outside of the moderate damage zone.**

If everyone in this area just stood outside for the first 24 hours – equating to a Protection Factor of 1 –

- ~280,000 people would receive enough radiation exposure to either make them sick (yellow / orange) or kill them (red).

Click #1

Even if everyone went into an inadequate structure like a small house – a Protection factor of 3—

- 150,000 people would be saved from significant exposure levels.

#2

If everyone goes into a “just adequate” shelter like a shallow basement or the poorest shelter location of a multistory building (on the top floor or the periphery of the ground floor), they would have a Protection factor of 10

- 245,000 people (out of 280,000) would be saved from significant exposure. Also, of the 40,000 remaining exposures, they are in the “sick, but not dead” category. This is why PF=10 is considered adequate..

#3

Finally, if everyone could get to the core of an office or an underground basement, where they would have a Protection Factor of 50 or more

- there would be no significant exposures to deadly radiation levels.

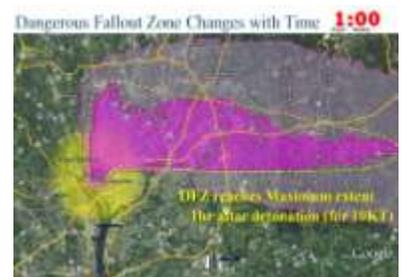
This is why the supporting science indicates that finding proper shelter after an IND is the best possible action the public can take and it could potentially save 100s of thousands of lives!

 Slide Transition –Animation begins

Fallout Changes with Time

Here are the Dangerous Fallout and Hot Zones 15 minutes after detonation

- For a 10kT, the Dangerous Fallout Zone reaches its maximum extent. After about 1 hour
- The yellow border represents the max extent of the DFZ.



Lets watch what happens as time progresses.

After about an hour, however, the dangerous area starts to shrink. This is due to the short half-life of many of the radionuclides produced.

So the key question is “how long should people remain in their shelter?”

3- Informed Evacuation

Optimum Shelter/Departure Example

 **Click –Informed evacuation route map appears**

Most people in the Dangerous Fallout zone will likely receive some exposure to fallout; this is unavoidable. However, knowing how long to shelter and the direction to evacuate can significantly lower the exposure. This example presumes an informed evacuation. This example presumes an informed evacuation. In this case the best possible route out of the area is West across Rock Creek Park. Unfortunately the victims in this area would not know that without outside help as other routes (away from the blast to the North) would look just as viable, but result in much higher evacuation exposures.

 **Click –School example appears**

This graph shows the total radiation dose received by someone sheltering inside a School with a protection factor of 50 (98 percent shielding). Dose rates will continue to rise depending on how long the person remains inside the School.

 **Click –Dose rate during evacuation appears**

The orange on the graph represents the additional exposure the person would receive while trying to evacuate the area **at the time specified**.

Notice how high the evacuation dose is if they were to leave in the first hour. That is because they are trying to evacuate while the radiation levels are highest outside.

The modelers have done extensive studies of the optimum time for departing a type of shelter.

 **Click –Inside exposure appears**

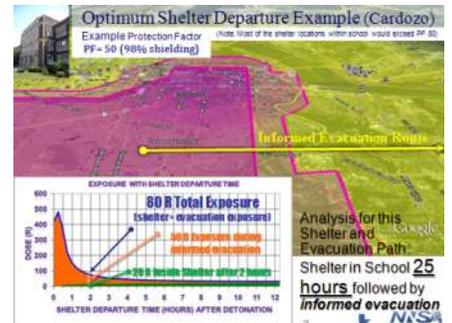
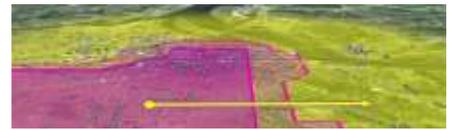
This graph shows the total radiation dose received by someone sheltering inside a School with a protection factor of 50 (98 percent shielding). Dose rates will continue to rise depending on how long the person remains inside the School.

 **Click –Dose rate during evacuation appears**

The orange on the graph represents the additional exposure the person would receive while trying to evacuate the area **at the time specified**.

Notice how high the evacuation dose is if they were to leave in the first hour. That is because they are trying to evacuate while the radiation levels are highest outside.

 **Click –Total dose rate appears**



- Even if you are in an excellent shelter like Cardozo, the longer you stay in the building, the greater dose you'll eventually accumulate.
- But if you leave a shelter too soon, the dose you receive during the evacuation itself – while you are walking or driving away -- would be much greater than if you stayed in the shelter and evacuated later.
- So it is a balancing act and these models come up with optimal departure times.

In this example, the best time to evacuate Cardozo HS would be 25 hrs after detonation,

and only then if you took the right evacuation path and it was clear.

Optimum Shelter Departure Time Depends on Shelter and Evacuation Route

Click – PF 3 example appears

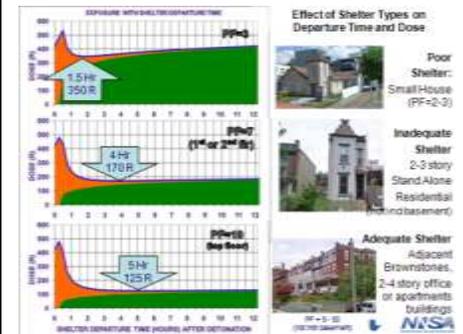
When to evacuate a shelter depends on how much protection a person is getting from the structure, and how long it will take an average person to complete the evacuation route. Knowing the answer to both of these is crucial to creating informed evacuation routes.

- In this example, the wood frame house offers poor protection. Although it does reduce the outside exposure by a factor of three, it is still not enough to warrant staying in the structure for very long. In fact, if the opportunity arises they should consider moving to a structure with more shielding.
- Inadequate Shelter (2-3 story) Stand Alone Residential (not incl basement) might only offer a PF =7, which would have an optimized evacuation of 4 hours
- Although Brownstones offer PF greater than 10 in the middle floors or English basement, a PF of 10 (adequate shelter) was considered for this analysis and resulted in a 5 hour departure time.

But the take away of this analysis is

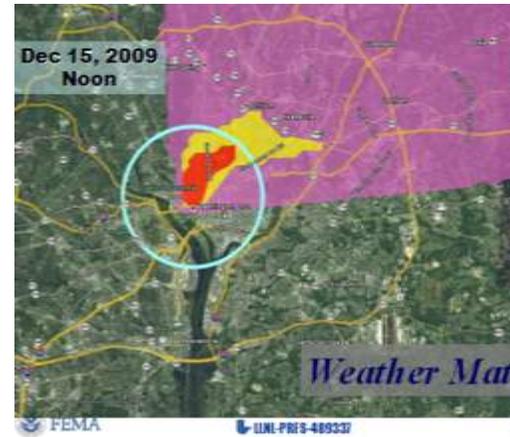
- 1) The average person won't have access to these models and
- 2) Whether you evacuate a shelter at the optimum point of 5 hours – or whether you wait up to 3 days – the difference in accumulated exposure is slight compared the hazard of early evacuation for most people.

Especially when you compare it to the dangerous doses you would receive if you evacuated in the first few hours after the detonation.



- The modeling and analysis presented here represent one possible scenario, it is important to recognize the yield, location of detonation, and the Weather (as demonstrated from these fallout patterns using the 14th of each month in 2009 demonstrates) all play an important role in the outcome and are difficult to predict in advance.

Do not write a plan for the specific scenario, but plan to the dynamic nature of the event as discussed.



Public Strategy Conclusion

Early, adequate shelter followed by informed, delayed evacuation

Click –Public Protection Strategy appears

Public Protection Strategy: Early, adequate shelter followed by informed, delayed evacuation. This includes:

- Adequate shelter includes houses with basements, large-multi-story structures, and underground spaces like parking garages or tunnels
- Sheltering the first hour in an adequate shelter can keep exposures non-lethal,
- The planning guidance recommends being prepared to shelter for 24 hours
 - Optimal shelter departure time will vary by shelter quality and evacuation path
 - Informed evacuation helps ensure rapid exit of the dangerous fallout zone

Click –Knowing what to do before the event is critical

By having response plans in place, and knowing where the best shelter is, many lives can be saved.

Have a family plan, have a kit for 24 hours (work and home), and a battery or hand crank radio.

Public Strategy

- **Public Protection Strategy: Early, adequate shelter followed by informed, delayed evacuation.**
 - Adequate Shelter is houses with basements, large multi-story structures, and underground spaces (e.g., parking garages and tunnels)
 - Sheltering for at least the first hour in an adequate shelter can keep exposures non-lethal
 - Be prepared to shelter for 24 hours
- **Knowing what to do and being prepared (at home AND work) before the event is critical.**



Up to this point, we've shown you can keep yourselves and your family safe after an IND detonation by the immediate action to find adequate shelter and stay there until you can make an informed evacuation.

In this module we'll move to the point of view of the responders and considerations when planning for how your community should respond to an IND detonation.



References

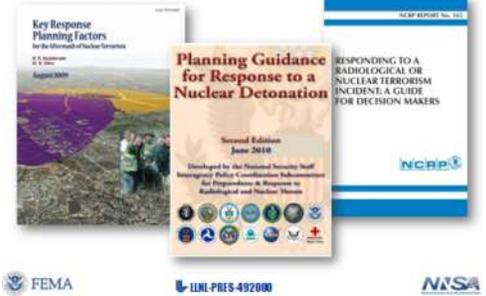
[Key Response Planning Factors for the Aftermath of Nuclear Terrorism](#) developed by Lawrence Livermore National Laboratory in support of the DHS preparedness activity was released in August 2009 reviews the science behind many of the recommendations noted in the video and above doctrine.

The guidance found in this presentation can be traced back to these three supporting documents:

[Planning Guidance for Response to a Nuclear Detonation](#). Developed by the Homeland Security Council, 2nd Ed, June 2010. This interagency consensus document provides excellent background information on the effects of a nuclear detonation and key response recommendations. Its definition of zones (damage and fallout) are becoming the standard for response planning and should be integrated in the planning process.

National Council on Radiation Protection and Measurement (NCRP) Report No. 165 - [Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers](#) was released Feb 2011 and is a National Standard that supplies the science and builds on many of the concepts of the Planning Guidance.

Supporting Documentation & Guidance



Immediate Emergency Alerts

An early priority for federal, state and local officials is to broadcast shelter in place messaging to the public through whatever means is available. Examples of scripted messages are in the federal Planning Guidance

- Communicating after a nuclear detonation will be difficult. The blast and electromagnetic pulse will damage communication infrastructure and devices for the population in the blast damage zones and potentially cause cascading effects in the surrounding areas, including the most critical region for communications – the dangerous fallout zone

Planners should collaborate on a regional approach in advance to determine the assets necessary to reestablish communications after

Emergency Broadcast Messages

- Communication infrastructure may be damaged, plan for multiple communication methods.
- Planners should select individuals with the highest public trust and confidence to deliver messages and should be prepared to deliver key information to the public in the affected areas about protection almost immediately in order to maximize lives saved.



a nuclear detonation.

- They should also identify and remedy gaps in their capabilities

After a nuclear detonation, use all information outlets when conveying messages including, but not limited to:

- television, radio, e-mail alerts, text messaging, and social media outlets

Planners must consider options for communicating in areas where the infrastructure for electronic communications has been disabled or destroyed.

- Any remaining operational communications systems will be severely overloaded.
- Communications into and out of the impacted area via these systems will be extremely difficult.
- Radio broadcasts may be the most effective means to reach the people closest to and directly downwind from the nuclear explosion site.

Pre-incident preparedness is essential to saving lives. After a nuclear detonation, public safety depends on the ability to quickly make appropriate safety decisions.

- Empowering people with knowledge can save thousands of lives.

Messages prepared and practiced in advance are fundamental to conveying clear, consistent information and instructions during an emergency incident.

Planners should select individuals with the highest public trust and confidence to deliver messages

 **Click –Defining Zones appears**

A well-thought out response plan can help maximize life-saving potential, and minimize the risks to emergency responders. When setting up a response plan, it is important to:

-  **Click -Identify Priority Zones:** Priority zones should be identified by deciding which zones have the best chance for saving lives without putting responders into conditions that are too dangerous for them. Look for areas that victims might have found shelter in, and help victims nearest the outside of structures first.

Zoned Approach to Response

- Defining zones can be a useful approach to planning:
 - Identify priority zones
 - Prioritize actions within each zone
 - Identify responder protection in each zone
 - Determining where to locate staging areas

“The goal of a zoned approach to nuclear detonation response is to save lives, while managing risks to emergency response worker life and health.”
—Planning Guidance for Response to a Nuclear Detonation

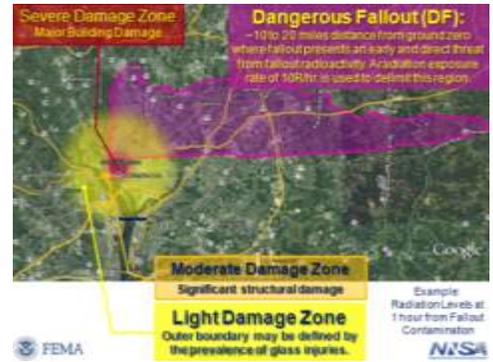
- 🔗 **Click -Prioritize Actions within Each Zone:** Determine the actions, in order, which will maximize the response. Determine which structures to enter first, estimate out how much time can be spent in each area before radiation doses get too high, and determine evacuation routes.
 - 🔗 **Click -Identify Responder Protection in Each Zone:** Ensure that responders are safe in each zone they enter. If responders decide they can enter a zone safely, ensure that adequate safety measures are taken based on the level of radiation and other possible hazards (debris, smoke, etc.) in the area. Use personal protective equipment (PPE) like dosimeters and respirators to ensure safety.
 - 🔗 **Click -Determine Where to Locate Staging Areas:** There may be multiple staging areas depending on the size of the blast. Staging areas may be set up along each zone to treat victims within those zones. A main staging area should also be set up in an area without any radiation, if possible. This staging area should be used for deploying responders and setting up response plans.
 - 🔗 **Click –Planning guidance quote appears –**“The goal of a zoned approach to nuclear detonation response is to save lives, while managing risks to emergency response worker life and health.” – from the Planning Guidance for Response to a Nuclear Detonation
- With proper response planning, many lives can be saved with minimal risk to the responders.

More Information on the DFZ

Here is some more crucial information about the DFZ:

- **Bounded by radiation levels of 10R/hr** – determining dose rates early on helps to identify the perimeters of the DFZ
- **Could reach 10-20 miles downwind** – it is important to know weather conditions for the day, to help determine how far, and where, the DFZ will extend to
- **Also called:**
 - ✓ High-Hazard Zone
 - ✓ And the Inner Perimeter

After establishing the perimeter of the DFZ, everyone should be aware that entering that area can cause acute radiation injuries or death. Responders should enter this area only voluntarily, and only after being fully informed of the risks.

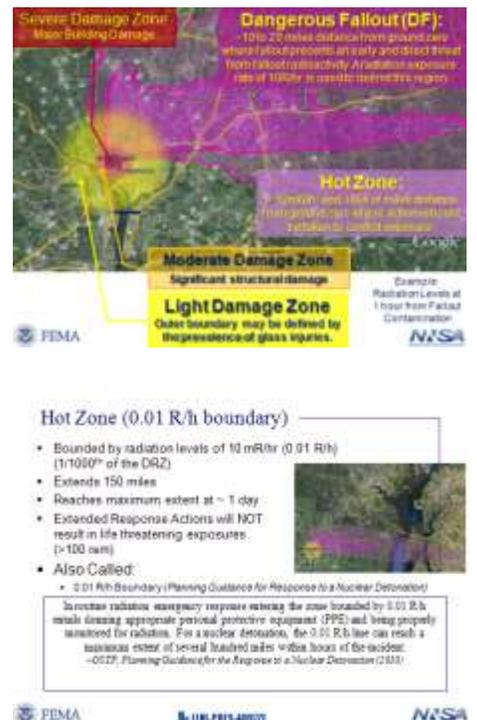


Hot Zone

Although it is not life threatening, responders need to be aware that there are significant areas outside of the DFZ that have radiation levels that will be easily detectable, and may even saturate many of the instruments.

- Bounded by radiation levels of 10 mR/h (1/1000th of the DRZ)
- For a 10KT, could extend 100s of miles
- Reaches maximum extent at ~ 1 day
- Extended Response Actions will NOT result in significant exposures (100 rem)

It is important to emphasize that response operations can and should continue in this area, though additional precautions are warranted to ensure that responders do not spend unnecessary time in the area and have the tools to alert them when they cross over to the DFZ.



Zone Priorities from Planning Guidance for Response to a Nuclear Detonation

- Most of the injuries incurred within the LDZ are not expected to be life threatening and would be associated with flying glass and debris from the blast wave and traffic accidents.
- If injured survivors are able to move on their own, they should be directed to medical care or assembly shelters.
- The MDZ should be the focus of early life-saving operations. Focus on medical triage with constant consideration of radiation dose minimization.
- Response within the SDZ should not be attempted until radiation dose rates have dropped and the MDZ response is significantly advanced.
- All response missions must be justified to minimize responder risks based on risk/benefit considerations built into worker safety plans.

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Priorities for Immediate Life Safety

The two most important aspects of a successful response effort are saving as many lives as possible and keeping responders safe.

In the case of an IND, saving lives involves a set Public Protection Strategy. To maximize life-saving potential, having everyone in the Dangerous Fallout Zone (DZF) seek immediate, adequate shelter followed by an informed, phased evacuation is the best course of action.

 **Click –Response Strategy appears**

In order to accomplish this, response personnel need to take a number of critical steps.

We will go into more detail on each of these, but the key point of this slide is the priority order. There may be an intuitive response to try and help nearby victims, but support to regional situation assessment can save far more lives in the long run.

Just they perform a “size up” of a scene, a regional “size up” is required to define the zones that are critical for immediate action. Just as important is defining low radiation hazard zones and communicating those to a central location so outside response elements know where it is safe to initially provide assistance.

Priorities for Immediate Life Safety

• Public Protection Strategy:

Early, adequate shelter followed by informed, phased evacuation

• Response Strategy:

1. Protect response personnel
2. Support regional situational assessment
3. Support public safety

From Key Response Planning Factors

With that information, the regionally coordinated response has the best potential to save and sustain lives and public safety.

Protecting Response Personnel

Again, keeping responders safe allows response efforts to continue, and as many lives as possible to be saved.

Steps to protecting responders include:

- **Responders without radiation detection instruments, follow the general public protection strategy – seek shelter and wait for informed evacuation instructions**

- **Click – Responders with radiation instruments, shelter using radiation detection equipment to monitor shelter conditions:**
 - ✓ **Click- Do not exit....appears** - wait until radiation levels are below 10R/hr, unless there is an immediate risk to safety like a fire or building collapse

 - ✓ **Click – Provided outdoor....appears –**
When outside radiation levels are below 10R/hr, responders can begin to perform scene assessment for hazards around their shelter.

Protect Response Personnel

- Responders without radiation detection instruments: Follow the general public protection strategy.
- Responders with radiation instruments: Shelter using radiation detection equipment to monitor shelter conditions.
 - Do not exit shelter or enter areas if radiation levels exceed 10R/hr unless there is a time critical life safety issue (e.g., avoiding fire or building collapse).
 - Provided outdoor radiation levels are below 10R/hr, perform scene assessment of the immediate area for hazards.

Responder PPE

- The best way to prevent radiation exposure is to avoid it. The only way to receive a lower dose of radiation is to avoid the DFZ. HAZMAT suits, respirators and SCBAs do not offer any protection against the primary hazard of radiation – penetrating gamma rays.
- Inhalation and ingestion are secondary concerns. Attempting to wear hazard suits or respirators will only slow down a responder and cause them to spend more time in dangerous areas. These suits have proven to reduce speed, the ability to communicate and cut down on worker efficiency.
- When working with dangerous levels of radiation, the best course of action is to simply stay out of the DFZ until radiation levels drop below 10R/hr and it is safe to enter and begin response efforts.
- This is why Radiation and Dose monitoring equipment are so important, as they can help you identify when you are in a hazardous radiation environment.
- **It is also important to consider all of the hazards, not just radiation. There will be fires, sharp metal and glass debris piles, and possibly other hazardous material in the air like the dust after the trade towers came down. These hazards need to be considered when selecting the right PPE.**

Personal Protective Equipment (PPE)

- SCBAs, Respirators, Firefighter "turnouts", Level A, B, or C HAZMAT suits do not protect against the primary hazard - the penetrating gamma radiation given off by fallout.



- Radiation / dose monitoring primary protection
- Inhalation & ingestion is a secondary concern compared to the external exposure.



Turnouts and anti-contamination clothing can help ease decontamination after entries, but not required for time-critical, life saving activities.

"Reducing the time spent in high dose-rate areas is the greatest protective measure. Bulky isolation suits and elaborate respiratory protection methods may actually increase exposure as they reduce the speed, the ability to communicate, and worker efficiency."

-Key Response Planning Factors for the Aftermath of Nuclear Terrorism

Decontamination Issues

Civil defense movies about fallout contamination. Click each movie to run (note: movies have sound!)

- **Entering Shelter:** Demonstrates how simple self-decontamination techniques (such as removing outer clothing, showering, and brushing away fallout material) are effective.
- **Fallout Decon:** Demonstrates simple techniques that were actually used at the Nevada Test Site to successfully decon large groups. Techniques should be used as the impacted population leaves the high-hazard zone or enters a shelter

Decontamination Issues



Entering Shelter



Actual Fallout Decon

- Simple self-decontamination techniques (such as removing outer clothing, showering, and brushing away fallout material) are effective.
- Techniques should be used as the impacted population leaves the high-hazard zone or enters a shelter

Support Regional Situational Assessment

Coordination can speed up response efforts and prevent unnecessary harm. Coordination is aided through regional situation assessment. This can be done by:

- **Designating a regional situational assessment center** – this should be outside of the DFZ and away from other hazardous conditions
- **Establishing communication with responders in the affected area** – be aware of conditions for responders in all affected areas, as well as their radiation dose reports
- **Report radiation levels in the area** – Responders in affected zones should continue to monitor outside dose rates until conditions are safe. Those in safe areas (areas where radiation levels are below 10R/hr) should also report dose rates to help determine safe evacuation routes and response staging areas.

Support Regional Situational Assessment

- Designate a regional situational assessment center
- Establish communication with responders in the affected area.
- Report approximate radiation levels in the area.
 - Identification of high hazard zones (reading greater than 10R/hr) is a priority, but
 - reporting safe areas (reading less than 10mR/hr) is also important for the determination of safe evacuation routes and response staging areas.

Fire Station Location Example

Knowing where the highest radiation levels are is crucial to responder safety. Knowing how to determine the DFZ can help responders know which areas to avoid, as well as which parts of the damage zones are safe to enter for response activities.

Fire station locations appear

These dots represent the fire stations in the NCR.

Assuming they are equipped with radiation detection instruments, the Responders in affected zones should monitor outside dose rates and report them to the assessment center.

Click –Dose rates appear

The fire stations that have turned dark purple on the map represent stations that are in the DFZ at ~ 1hr.

The responders should know (as they see the readings at the door) to go back inside and shelter for their own protection.

Also, by finding a way to report their radiation readings (along with their brethren in the Hot Zone (yellow) or Cold Zone (White), a pattern can be determined.



🖱️ **Click –DFZ lines appear**

After determining the pattern of fire stations with 10R/hr and higher ratings, perimeters for the DFZ can be established. The nice thing is that exact numbers (dose rates) are not required, just report which Zone you are in is sufficient.

🖱️ **Click –plume model appear**

As can be seen, this simple method can quickly determine the hazard zone to help guide a response, without even having to report exact numbers or having to rely on a model.

Support to Public Safety

Although “shelter in place” broadcast messages can begin immediately, most offensive response actions will require knowledge of the hazard zones, particularly the DFZ so we know the areas to avoid and can begin preparing a Public Safety plan.

Once the DFZ is established, response actions such as safe staging areas, injured extractions, and firefighting can begin that make the best use of response actions.

Some actions can be performed in the DFZ, but they require such a significant amount of support that it is not an effective use of limited response resources.

We mentioned the Moderate Damage Zone is the best place to apply response resources, but we haven’t said why yet.

FEMA modelers took the average daytime population data for the DC area and overlaid the damage caused by Prompt Effects from our scenario.

Click: 150 K in the Severe Damage Zone
Unfortunately most of these people would not survive.

Click: 200K in the Moderate Damage Zone
The pie chart represents the types of injuries that might be seen in this area.

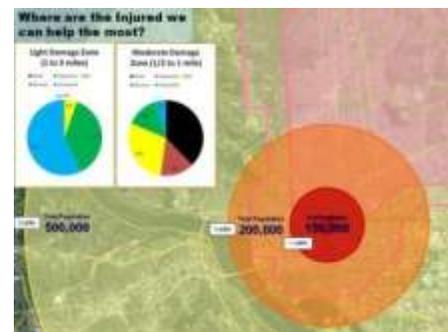
- In this area, there are more initial survivors than fatalities, though a large % of these survivors (almost 30%) would be seriously injured and would most benefit from advanced medical care.

Support Public Safety

- Use emergency broadcast systems to shelter populations
- Once the DFZ has been determined, the following activities can occur *outside* of the DFZ:
 - Establish reception centers and triage sites
 - Direct response resources to the moderate Damage Zone to support injured extraction
 - Fight fires and control hazards



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Click: and 500K in the Light Damage Zone

But notice that in the LDZ – at distances greater than 1 mile from ground zero –

- There would be few deaths attributed directly to Prompt Effects and, in fact, over half the people in this area would be uninjured.
- The second biggest LDZ injury class (in green) are with injuries that are not life threatening, even without medical assistance; these include lacerations, minor crush, and eye injuries.

Offensive Response

🔗 Click –Initial Priority: MDZ

The MD zone should be the focus of nuclear explosion emergency response efforts, with the goal of managing the impacted scene through aggressive rubble removal and site access, fire suppression, and structural and utility stabilization, in order to facilitate expeditious search and rescue and medical triage. On a city-specific basis, response planners should develop plans for MD zone response that includes:

- Establishing nuclear emergency response procedures that maximize rescue operations focused on survivable victims
- Minimizing the total risk to responders
- Organizing neighboring response units (and sharing such plans with the State emergency management officials so they will be aware which jurisdictions would be stepping in)
- Pre-deploying appropriate supplies to locations likely to contain large populations, including fallout shelters or subways
- Deploying radiation assessment teams, engineering response teams (e.g., road clearing, debris hauling, and stabilization capabilities), Hazmat, search and rescue teams, medical response teams, and law enforcement (to secure the scene)

The MD zone should be the focus of early life-saving operations. Early response activities should focus on medical triage with constant consideration of radiation dose minimization.

🔗 Click –Secondary Priority

Response within the SD zone should not be attempted until radiation dose rates have dropped substantially in the days following a nuclear detonation, and the MD zone response is significantly advanced. All response missions must be justified to minimize responder risks based on risk/benefit considerations built into worker safety plans.

3. Evacuation

Recommended Response Priorities



Evacuation Considerations

The first bullet on this slide speaks to the fact that --Even during the initial (most dangerous) phases of the event -- we can't let "tunnel vision" which focuses solely on the radiation hazard -- take our sights off of all the other life safety issues.

- In particular, it does no good to shelter from the radiation if your shelter collapses on you or is on fire.

We need to ensure that the public knows that other life threatening hazards can take priority.

Ideally, Our First Responders are in their stations and they've been reporting back their radiation readings back to the regional assessment center

- That center has at least an initial indication of where the DFZ and Hot Zones are.

Several hours (or days) into the event public safety agencies should have a better handle on potential evacuation routes out of the elevated radiation areas.

- If these evacuation routes are blocked, they should be attempting to clear them.
- This is easier said than done. Remember one of the first animations we showed was the highway littered with wrecked vehicles caused by flash blindness.
- Having situational awareness of the state of evacuation routes will be imperative before advising the public to evacuate!
- Routes that take advantage of sheltered passage (subways, underground connectors, through building lobbies) should be used whenever possible

Most people in the Dangerous Fallout zone will likely receive some exposure to fallout; this is, unfortunately, unavoidable.

- However, knowing how long to shelter and the direction to evacuate can significantly lower the exposure.

When to evacuate a shelter depends on how much protection a person is getting from the structure, and how long it will take an average person to complete the evacuation route.

So the key question is "how long should people remain in their shelter?"

- The federal planning guidance recommends 12-24 hours, unless you receive alternate instructions or you are threatened by fire, building collapse, or other life threatening emergency.

Evacuation Considerations

- Those in shelters threatened by fire, building collapse, or other life endangering hazard should evacuate or relocate immediately.

Once DFZ and 0.01 R/h Boundary are established

- Evacuation planning should begin to move sheltered populations out of harms way.
- Evacuation routes should be cleared if possible
- Routes that take advantage of sheltered passage:
 - subways,
 - underground connectors, and
 - building lobbies
- Execution should be phased to reduce the time spent transiting through fallout areas



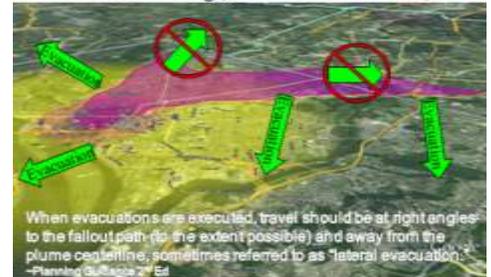
Evacuation Strategies

As stated in the planning guidance:

When evacuations are executed, travel should be at right angles to the fallout path (to the extent possible) and away from the plume centerline, sometimes referred to as “lateral evacuation.”

For more complex fallout patterns like the one pictured here, ensure that evacuations move people down the length of the fallout pattern or into another fallout contamination area.

Evacuation Planning (After Initial Shelter Period)



4. Conclusions

This slide demonstrates the areas that can lead to acute effects, the initial blast zones where there could be injuries from flying glass and debris out to 3 miles, and the dangerous fallout area could extend for 10-20 miles.

 **Click –Animation begins**

As you can see, the areas of potential injury are small when compared to the resources of the area. While it will still be devastating, it is not the “nuclear end-all” situation that many people envision when they think about a nuclear bomb and there are a lot of resources in the surrounding area that can safely help save and sustain lives... If they know what to do!

Putting It Into Perspective



Early, adequate shelter followed by informed, phased evacuation

- It is important *to be in the shelter when the fallout arrives.*
- There should be *several minutes* before fallout arrives.
- If you are outside or in a car, seek the nearest adequate shelter.
- If you are already in an adequate shelter, shelter in place.
- *Adequate Shelters* are Protection Factor 10 or higher

- **Protect Response Force**
 - Shelter until hazard identified
 - Provide PPE and Zone priorities
- **Local Emergency Management:**
 - Establish early public communication
 - Rapid identification of hazard zones
 - Established coordinated safe evacuation routes
 - Identify priority candidates for early shelter departure (i.e., those in inadequate shelters or threatened by other hazards)

Conclusions

- Public Protection Strategy: Early, adequate shelter followed by informed, phased evacuation
- Response Strategy:
 - Protect Response Force
 - Rapid identification of hazard areas and safe evacuation routes
 - Establish communication (Responder and Public)
- First hour most critical
- 100,000s of people can be saved through proper action (both individual action and leadership)
- Situational awareness, communication, and independent responder actions essential
- Knowing what to do before the event is critical

- **The first hour is the most critical** – The worst radiation doses will be received within the first hour following detonation of the IND. If everyone can seek immediate, adequate shelter, 100,000s of lives can be saved.
- **100,000s of people can be saved through proper action (both individual and leadership)** – Again, if residents are aware of that they must seek an adequate shelter immediately, many lives will be saved. After the detonation, leadership roles must be quickly established (preferably based on decisions made from prior response planning documents), and decisions about damage zones, the DFZ and evacuation results must be made quickly.
- **Situational awareness and communication will be difficult, but essential** – Communication systems may be down following detonation. It is critical that these systems be quickly reestablished, and responders know that the priority is to report radiation readings and emergency broadcast messages are broadcasted to the public. Anyone in a response capacity must be aware of their surroundings, and realize that they may have to wait to start response until they are not in danger from radiation.
- **Knowing what to do before the event is critical** – Prior response planning and training for responders and the public is the key to saving many lives after detonation of an IND.
- **Rapid, independent responder actions are also key** – Many responders may not be able to assist initially due to their locations within the DFZ. Other responders must be able to carry out actions in a situation where they are temporarily without leadership.

Additional Slides / Topics

- Also realize that this presentation has focused on the immediately life threatening levels of radiation. Lower levels of fallout contamination, enough to represent long term cancer concerns will remain an issue for months after the detonation.

In fact, this image demonstrate how large the Hot Zone is even after a week, over 20 miles long!

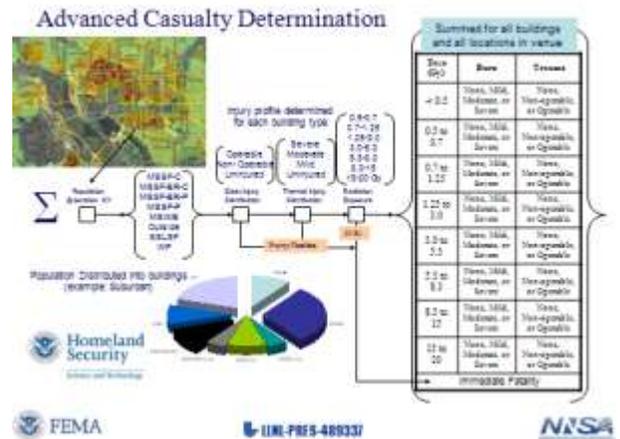
Additional Slides / Topics



Advanced Casualty Determination Section under Development

Although each effect (blast, thermal, and radiation) is discussed separately, the consequences they create impact the same population. In order to effectively model medical countermeasures, the nature and type of injuries must be known for the effected population.

DHS Science and Technology undertook a detailed, block by block, injury analysis as part of an overall risk assessment. In this analysis, the impacts of an IND detonation were evaluated for the affected population by distributed them into likely structures based on the detonation occurring during a typical workday. The effects of blast, thermal, and ionizing radiation are then calculated for each structure and the population within the structure. Details on the types of injuries are sorted into 97 different casualty codes, which are then summed across all buildings in all the locations in the venue. The Slide illustrates this process.



Another, poorly understood, long range prompt effect is glass breakage. Most of the injuries outside of the Murrah building in the 1995 Oklahoma City bombing were caused by this phenomenonⁱ. Extrapolating from more recent work on conventional explosivesⁱⁱ, a 10kt explosion could break certain types of windows (e.g., large monolithic annealed) over 8 miles away. Also noted in this same study was the tendency for glass to fail catastrophically even at extreme ranges, causing severe injury to those behind it. NATO medical response planning documentsⁱⁱⁱ for nuclear detonations state that "... missile injuries will predominate. About half of the patients seen will have wounds of their extremities. The thorax, abdomen, and head will be involved about equally." A significant number of victims from Nagasaki arriving at field hospitals exhibited glass breakage injuriesⁱⁱⁱ.

Lessons from Non-Nuclear Explosions

For unwarned (more importantly unprepared) populations, window breakage injuries (especially eye injuries) were the most common injury mechanism outside of the Oklahoma City building and in the town near the Halifax explosion.

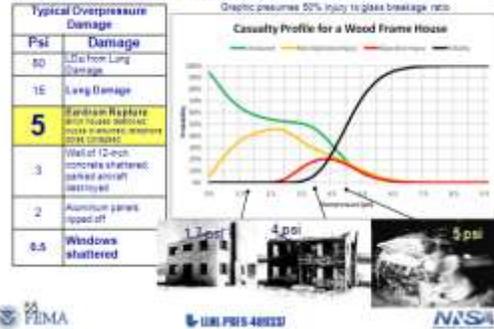


"Most injuries among survivors of bombings have been shown to result from secondary effects of the blast by flying and falling glass, building material, and other debris." Despite the relative small surface area exposed, ocular injury is a frequent cause of morbidity in terrorist blast victims.

Previous models for human effects from blast stop at 5 psi (the threshold for eardrum rupture), yet you can see from the image a house at 5 psi can be easily destroyed. An occupant in a house undergoing the destruction pictured might get more than an eardrum rupture. Advanced modeling now accounts for the collapse, severe damage, or glass breakage to the structure and the subsequent effects on the occupants.

Recent analysis work helped better understand the relationship between people and the urban environment. Most of the injuries outside of the Murrah building in the 1995 Oklahoma City bombing were caused by glass injury, not direct blast effects. A significant number of victims from Hiroshima and Nagasaki arriving at field hospitals exhibited glass breakage injuries, but this effect has not been previously modeled.

Accounting for Glass and Blast Injuries



Burn Injury

Although the line of sight blockages in the modern urban environment will greatly reduce the number of burns from a ground level detonation, there still may be a significant number of burns from secondary effects such as house and car fires.

Burn Injury (Secondary)

- Burns from **secondary fires** likely to be a primary thermal injury mechanism
 - Based on burns caused by building collapse during earthquakes, this event could result in 1,700 burn patients.
 - 200 have mild burns.
 - 650 have moderate burns
 - 900 have severe burns.
- (information from Gryphon Scientific)*



Radiation Injury

This section will focus on immediate injuries, which are those that occur from thermal burns, trauma, or enough radiation exposure to cause acute radiation syndrome (sickness) or complicate other injuries.

This chart can help put the exposure numbers we are referring to in perspective.

Radiation Injury

TABLE 4.3—Approximate acute death, acute symptoms, and lifetime fatal cancer risk estimates as a function of whole-body absorbed dose (in rads), for use in damage modeling after short-term radiation exposure (adapted from APF01, 2001; Green and Wasson, 2001; FEMA, 1996; ICRP, 1992; Marder and Epine, 1993).

Short-Term Whole-Body Dose (rad/100)	Acute Death* Without Medical Treatment (%)	Acute Death* from Radiation with Medical Treatment (%)	Acute Symptoms (onset and severity within 4 hr) (%)	Lifetime Risk of Fatal Cancer from Whole-Body Radiation Exposure (%)	Estimated Risk of Fatal Cancer Due to Short-Term Radiation Exposure* (%)
1 (0.01)	0	0	0	24	0.00
10 (0.1)	0	0	0	24	0.0
50 (0.5)	0	0	0	24	4
100 (1)	<5	0	0-30	24	8
200 (2)	<5	<5	40	24	12
300 (3)	0	<5	60	24	16
400 (4)	0	0-50	75	24	20 ^b
600 (6)	0-100	0-100	100	24	30 ^b
1,000 (10)	100	100	100	24	100 ^b

*Based on NCRP Commentary No. 19 - Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism (2006).

^aThese levels refer to the radiation exposure during the initial response to the incident. The acute effects listed are likely to be reduced by about one half if radiologic response occurs over weeks.

^bAcute deaths are likely to occur from 24 to 100 d after exposure and are of any other than hematopoietic or digestive origin. Individuals with other injuries, and children, will be at greater risk.

^cThese estimates are not likely to occur until several decades after exposure, although induction time is shorter latency period (1-3 y).

^dApplies to those individuals that survive 30 d.

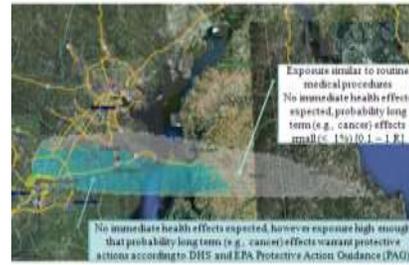
Long Rang Potential Health Effects

The white are represent levels that are below the EPA and DHS recommendation for shelter or evacuation (1 rem in 4 days) and the exposure is similar to routine medical procedures
 No immediate health effects expected, probability long term (e.g., cancer) effects small (< 1%).
 Even so, protective measures to reduce exposure will likely be performed as good ALARA practice.

In the light blue areas, there would also be No immediate health effects expected, however exposure high enough (1 to 100 rem) that probability long term (e.g., cancer) effects warrant protective actions according to DHS and EPA Protective Action Guidance.



FEMA LLNL-PRES-489337 NNSA



FEMA LLNL-PRES-489337 NNSA [1 - 100 R]

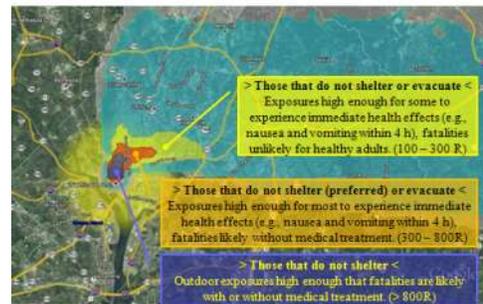
Close in Exposure Concerns

Within 10 – 20 miles of the detonation, exposures from fallout are high enough to cause near term (hours) symptoms such as nausea and vomiting. The Area in Yellow represents and OUTDOOR exposure of 100 – 300 R. In this case the area is about 6 miles long and the exposure happened early, within the first hours of fallout arrival so “evacuating” would not be easy.

> Those that do not shelter (preferred) or evacuate the ORANGE Area<

Exposures high enough for most to experience immediate health effects (e.g., nausea and vomiting within 4 h), fatalities likely without medical treatment. (300 – 800R)

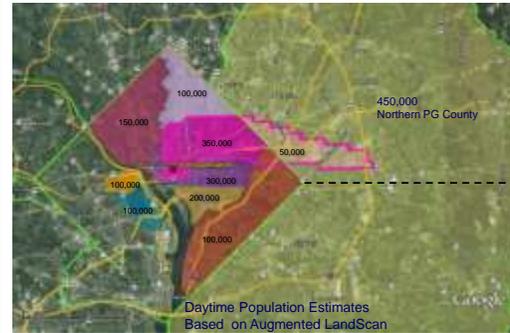
> Those that do not shelter in the Blue area <
 Outdoor exposures high enough that fatalities are likely with or without medical treatment. (> 800R)
Evacuation is not an option in this area as the fallout would arrive too quickly (~ 10 minute) to evacuate.



FEMA LLNL-PRES-489337 NNSA

This is the Daytime population in the key areas of our nuclear scenario.

Note that the Dangerous Fallout Area has ~ 400,000 people






Light Damage Zone (1 to 3 miles) 444,111
 Moderate Damage Zone (1/2 to 1 mile) 215,015
 Severe Damage Zone (< 0.8km) 176,768

Although there were survivor directly under the Hiroshima detonation, the Severe damage Zone is not expected to have a significant fraction of survivors.

However, in the Moderate Damage Zone, the number of initial survivors outweighs the number of prompt fatalities. ~30% of the these survivors have a severe enough injury that they would greatly benefit from medical assistance.

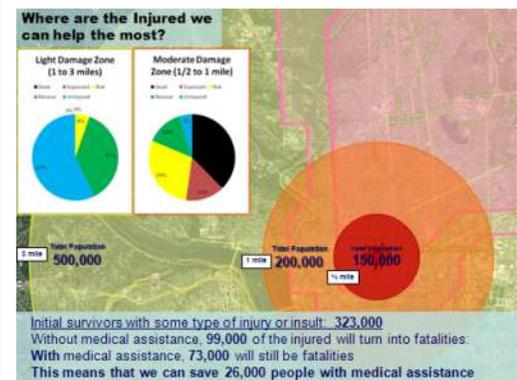
In the Light damage Zone, most (~ 60%) of the population is uninjured. Almost all of the remaining population has relatively minor injuries (minor crush, glass laceration, and eye injures) and will survive without immediate care.

Initial survivors with some type of injury or insult:
323,000

Without medical assistance, **99,000** of the injured will turn into fatalities:

With medical assistance, **73,000** will still be fatalities

This means that we can save 26,000 people with medical assistance



In Analyzing the injury categories, 3 injury types represent the largest number of victims who's represent the largest life sustaining categories:

Low exposure (< 125 R), mild trauma: 175,000 people

~4,000 of the ~5,000 potential fatalities can be saved with medical care

These will generally be populations that are upwind of the fallout but in the light on moderate damage zones (LDZ & MDZ). In the case of our Feb 14 scenario, this means South and West DC and Virginia.

Since the injury of concern is trauma, a prompt medical support (<12 hours) will be most effective. Since the number of potential mortalities is only 3% of the overall population in this category, separating and saving the ones on a mortality trajectory may be difficult.

Moderate Exposure (125 – 300R), with and without mild trauma: 60,000 people

~10,000 of the ~15,000 potential fatalities can be saved with medical care

This represents the greatest life saving potential. The radiation levels are high enough to complicate an injury or recovery, but not so high as to be acutely life threatening.

Since the primary mortality mechanism is complications (i.e. immune-suppression) from ARS, medical care can be applied throughout the acute radiation syndrome (ARS) stages to improve prognosis (even as late as weeks later), however early intervention, especially with anti-Neutropenics, can greatly improve outcomes. These survivors will come from downwind areas in dangerous fallout zone (DFZ), also often in the light damage zone (LDZ).

Significant Exposure (300– 530R), with and without mild trauma: 33,000 people

~10,000 of the ~25,000 potential fatalities can be saved with medical care

Although a significant life saving potential, these individuals will require sooner (<3 days) and more intensive care than those with less severe exposures (above). Even with advanced medical

Primary Injury Categories

Low exposure (< 125 R), mild trauma: 175,000 people

~4,000 of the ~5,000 potential fatalities can be saved with medical care

These will generally be populations that are upwind of the fallout but in the light on moderate damage zones (LDZ & MDZ). In the case of our Feb 14 scenario, this means South and West DC and Virginia. Since the injury of concern is trauma, a prompt medical support (<12 hours) will be most effective. Since the number of potential mortalities is only 3% of the overall population in this category, separating and saving the ones on a mortality trajectory may be difficult.

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This represents the greatest life saving potential. The radiation levels are high enough to complicate an injury or recovery, but not so high as to be acutely life threatening.

Since the primary mortality mechanism is complications (i.e. immune-suppression) from ARS, medical care can be applied throughout the acute radiation syndrome (ARS) stages to improve prognosis (even as late as weeks later), however early intervention, especially with anti-Neutropenics, can greatly improve outcomes. These survivors will come from downwind areas in dangerous fallout zone (DFZ), also often in the light damage zone (LDZ).

Significant Exposure (300– 530R), with and without mild trauma: 33,000 people

~10,000 of the ~25,000 potential fatalities can be saved with medical care

Although a significant life saving potential, these individuals will require sooner (<3 days) and more intensive care than those with less severe exposures (above). Even with advanced medical care ~50% will perish.

These candidates come from the area where the DFZ overlaps the LDZ and MDZ.



LLNL-PRES-489337



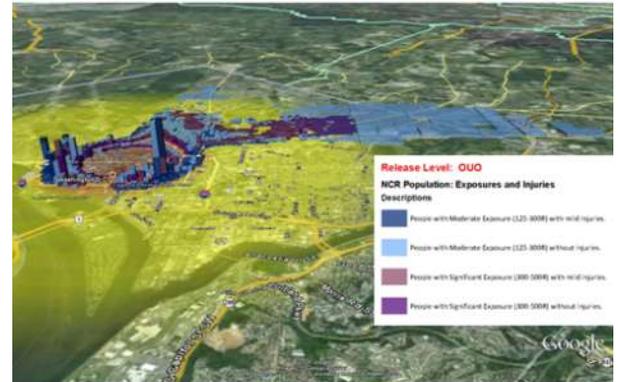
care ~50% will perish.

These candidates come from the area where the DFZ overlaps the LDZ and MDZ.

Location of Moderate and Significant exposed individuals.

This graphic demonstrates where the second Moderate (Blue) and Significant (Purple) exposed individuals would be. **Note that this assumes 2 hours of outdoor fallout exposure**, much of which could be mitigated through the practice of shelter.

The height of each bar represents the number of injured at that location. You can see how this reinforces the importance of the moderate damage zone rescue operations.



Zone Review

Click –Severe Damage Zone appears

The Severe Damage Zone extends to about half a mile from the blast site. This zone will see severe structure damage from the initial blast wave, and most likely fatal injuries from the blast, thermal pulse, and prompt radiation.

Click –Moderate Damage Zone appears

From ½ a mile to 1 mile from the blast site of a 10KT is the moderate damage zone, This is the area with a large number of significant injuries and represents the area with the most life-saving potential.

This area has significant structural damage and fires. Victims in this area have the greatest chance of avoiding deadly radiation doses by seeking shelter immediately.

•



Severe Damage Zone (SDZ):

- Few, if any, buildings are expected to be structurally sound or even standing
- Very few people would survive; however, some people protected within stable structures (e.g., subterranean parking garages or subway tunnels) at the time of the explosion may survive the initial blast.
- Very high radiation levels and other hazards are expected in the SDZ, significantly increasing risks to survivors and responders. Responders should enter this zone with great caution, only to rescue known survivors and with appropriate radiation monitoring equipment.
- Rubble in streets is estimated to be impassable in the SDZ making timely response impracticable.
- The SDZ may have a radius on the order of a 0.5 mile (0.8 km) for a 10 KT detonation. Blast overpressure that characterizes the SDZ is 5–8 psi and greater.

Moderate Damage Zone (MDZ):

- Responders may expect they are transitioning into the MDZ when building damage becomes substantial. This damage may correspond to a distance of about one mile (1.6 km) from ground zero for a 10 KT nuclear explosion. The determination is made by ground-level and/or overhead imagery.
- Observations in the MDZ include significant structural damage, blown out building interiors, blown down utility

Recognizing the Severe Damage Zone

- Few, if any, buildings are expected to be structurally sound or even standing
- Very few people would survive; however, some people protected within stable structures (e.g., subterranean parking garages or subway tunnels) at the time of the explosion may survive the initial blast.
- Very high radiation levels and other hazards are expected in the SDZ, significantly increasing risks to survivors and responders. Responders should enter this zone with great caution, only to rescue known survivors.
- Rubble in streets is estimated to be impassable in the SDZ making timely response impracticable.



Recognizing the Moderate Damage Zone

- Responders may expect they are transitioning into the MDZ when building damage becomes substantial, such as blown out building interiors, blown down utility lines, overturned automobiles, caved roofs, some collapsed buildings, and fires.
- In the MDZ, sturdier buildings (e.g., reinforced concrete) will remain standing, lighter commercial and multi-unit residential buildings may be fallen or structurally unstable, and many wood frame houses will be destroyed.
- The MDZ is expected to have the highest proportion of 'survivable victims' who require medical treatment.
- The MDZ presents significant hazards to response workers, including elevated radiation levels, unstable buildings and other structures, downed power lines, ruptured gas lines, hazardous chemicals, asbestos and other particulates released from damaged buildings, and sharp metal objects and broken glass, for which consideration and planning is needed.



lines, overturned automobiles, caved roofs, some collapsed buildings, and fires. Some telephone poles and street light poles will be blown over. In the MDZ, sturdier buildings (e.g., reinforced concrete) will remain standing, lighter commercial and multi-unit residential buildings may be fallen or structurally unstable, and many wood frame houses will be destroyed.

- Substantial rubble and crashed and overturned vehicles in streets are expected, making evacuation and passage of rescue vehicles difficult or impossible without street clearing. Moving towards ground zero in the MDZ, rubble will completely block streets and require heavy equipment to clear.
- Within the MDZ, broken water, gas, electrical, and communication lines are expected and fires will be encountered.
- The MDZ is expected to have the highest proportion of **'survivable victims'** who require medical treatment.
- The MDZ presents significant hazards to response workers, including elevated radiation levels, unstable buildings and other structures, downed power lines, ruptured gas lines, hazardous chemicals, asbestos and other particulates released from damaged buildings, and sharp metal objects and broken glass, for which consideration and planning is needed.

 **Click –Light Damage Zone appears**

- Damage is caused by shocks, similar to those produced by a thunderclap or a sonic boom, but with much more force. Although some windows may be broken over 10 miles (16 km) away, the injury associated with flying glass will generally occur at overpressures above 0.5 psi. This damage may correspond to a distance of about 3 miles (4.8 km) from ground zero for a 10 KT nuclear explosion. The damage in this area will be highly variable as shock waves rebound multiple times off of buildings, the terrain, and even the atmosphere.
- As a responder moves inward, windows and doors will be blown in and gutters, window shutters, roofs, and lightly constructed buildings will have increasing damage. Litter and rubble will increase moving towards ground zero and there will be increasing numbers of stalled and crashed automobiles that will make emergency vehicle passage difficult.



- Blast overpressures that characterize the LDZ are calculated to be about 0.5 psi at the outer boundary and 2–3 psi at the inner boundary. More significant structural damage to buildings will indicate entry into the moderate damage zone.
- Much of the LDZ may be essentially non-radioactive. However, responders should be prepared to encounter elevated radiation. The most hazardous radiation levels would be associated predominantly with the major path where fallout deposition overlays the LDZ.
- The severity of injuries responders will encounter in the LDZ should be relatively light and, consist of mostly superficial wounds with occasional flash burns. Glass and other projectile penetrations are expected to be superficial (i.e., about ¼ inch depth) in the torso, limbs, and face. Eyes are particularly vulnerable. As responders proceed inward they will begin to observe an increasing frequency and severity of injuries from flying glass and debris, and crush, translation, and tumbling injuries.

Recognizing the Light Damage Zone

- Nearly all windows will be broken and there will be external panel damage on most structures.
- The damage in this area will be highly variable as shock waves rebound multiple times off of buildings, the terrain, and even the atmosphere.
- As a responder moves inward, windows and doors will be blown in and gutters, window shutters, roofs, and lightly constructed buildings will have increasing damage.
- The severity of injuries responders will encounter in the LD zone should be relatively light and, consist of mostly superficial wounds with occasional flash burns.



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Movie demonstrating the dynamic nature of the DFZ and 0.01R/r Boundary

The ‘Silver Lining’ of radiation is the short half-life; it decays extremely rapidly.

This animation shows how fallout reaches its peak after about an hour, than begins to recede, but the 0.01 R/h boundary will continue to grow as material is deposited. It will reach its max extent in ~1 days.

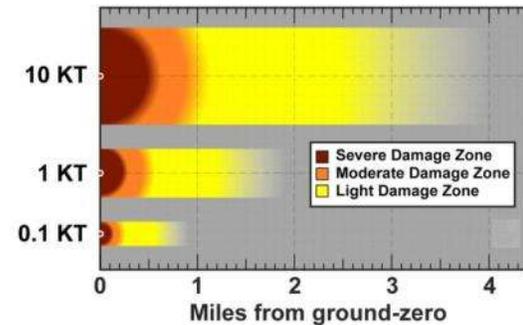
Dangerous Fallout Zone Changes with Time **1:00**



Damage Zone Ranges Change with Yield

The size of the IND determines the area covered by each damage zone. It is important to have some idea of the detonation size to help determine zones when starting the response process. Failing to do this could cause harm to emergency responders.

Damage Zone Ranges Will Change With Yield

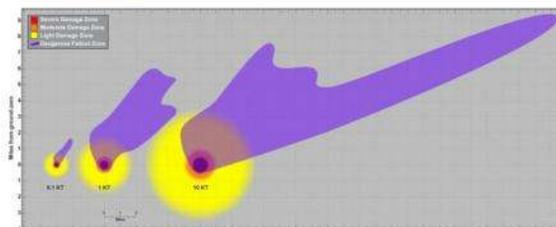


Radiation Zones Take Precedent

When determining damage zones, radiation levels must also be taken into account. After determining the path of the dangerous radiation zone from fallout, certain rules will apply. These are:

- **The dangerous radiation zone from fallout will overlap damage zones**
- **When zones overlap, radiation precautions take precedent** – even if responders know there are victims within the moderate and light damage zones, they should not enter until dangerous radiation levels are no longer present
- **Initial efforts should focus on the portions of the damage zones that are outside the dangerous radiation areas** – responders should initially wait to enter areas within the light and moderate damage zones, and focus on responding to areas outside of the dangerous fallout zone

Dangerous Fallout Zone Precautions Take Precedent



- The Dangerous Fallout Zone (DFZ) will overlap the damage zones
- When zones overlap, DFZ precautions take precedent.
- Initial efforts should focus on the portions of the damage zones that are outside of the DFZ

ⁱ Safety Solutions, Posted: 15 October 2005, “Preventing glass from becoming a lethal weapon.”

www.safetysolutions.net.au, Retrieved on November 1, 2007.

ⁱⁱ Applied Research Associates, Inc., 2004, Injury based glass hazard assessment: range-to-effect curves, Sponsored by US Army Technical Center for Explosives Safety, DACA45-02-D-0004.

ⁱⁱⁱ Akizuki, T., 1981, Nagasaki, 1945. Quartet Books, London, UK.